6-D
PERMANENT STORMWATER MANAGEMENT AT THE TREATMENT PLANT SITES

FINAL ENVIRONMENTAL IMPACT STATEMENT

Brightwater Regional Wastewater Treatment System

APPENDICES

Brightwater
TREATMENT SYSTEM

Final

Appendix 6-D
Permanent Stormwater Management at the Treatment Plant Sites

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King County has prepared a Draft Environmental Impact Statement (Draft EIS) and Final Environmental Impact Statement (Final EIS) on the Brightwater Regional Wastewater Treatment System. The Final EIS is intended to provide decision-makers, regulatory agencies, and the public with information regarding the probable significant adverse impacts of the Brightwater proposal and identify alternatives and reasonable mitigation measures.

King County Executive Ron Sims has identified a preferred alternative, which is outlined in the Final EIS. This preferred alternative is for public information only, and is not intended in any way to prejudge the County's final decision, which will be made following the issuance of the Final EIS with accompanying technical appendices, comments on the Draft EIS and responses from King County, and additional supporting information. After issuance of the Final EIS, the King County Executive will select final locations for a treatment plant, marine outfall, and associated conveyances.

The County Executive authorized the preparation of a set of Technical Reports, in support of the Final EIS. These reports represent a substantial volume of additional investigation on the identified Brightwater alternatives, as appropriate, to identify probable significant adverse environmental impacts as required by the State Environmental Policy Act (SEPA). The collection of pertinent information and evaluation of impacts and mitigation measures on the Brightwater proposal is an ongoing process. The Final EIS incorporates this updated information and additional analysis of the probable significant adverse environmental impacts of the Brightwater alternatives, along with identification of reasonable mitigation measures. Additional evaluation will continue as part of meeting federal, state, and local permitting requirements.

Thus, the readers of this Technical Report should take into account the preliminary nature of the data contained herein, as well as the fact that new information relating to Brightwater may become available as the permit process gets underway. It is released at this time as part of King County's commitment to share information with the public as it is being developed.

1 INTRODUCTION AND GENERAL APPROACH

Construction of a large wastewater treatment plant, such as the one for the Brightwater system, has the potential to increase stormwater runoff. This can damage streams, degrade water quality, and cause downstream flooding. Stormwater regulations have evolved in the region over several decades, and stormwater management is now more important than ever with the recent addition of several of the region's fish species to the federal endangered list.

Stormwater facilities will therefore be a major component of Brightwater and are discussed in this memorandum. References and figures cited herein can be found at the end of the memorandum.

1.1 Stormwater Requirements

In 2001 the Washington Department of Ecology (Ecology) produced a guidance document for stormwater management (Ecology, 2001), known informally as the Ecology

Manual. Brightwater stormwater facilities will follow the Ecology Manual except where the local jurisdiction requires more conservative design, in which case the local regulations will be followed. The Ecology Manual outlines 10 minimum requirements for stormwater management, summarized below. Minimum requirements #6 and #7 are emphasized because they have played a major role in the layout and sizing of the Brightwater stormwater facilities.

Minimum Requirement (MR) #1, Stormwater Site Plan – This will apply immediately prior to and during construction of the project.

MR #2, Construction Stormwater Pollution Prevention – This is partly addressed in Appendix 6-C, Management of Water Quality During Construction at the Treatment Plant Sites, and will be fully addressed in the design phase.

MR #3, Source Control of Pollution – The project will take major steps to assure that potential pollution is controlled at the source. This is discussed further in Section 1.3.

MR #4, Preservation of Natural Drainage Patterns – Stormwater from the Route 9 site will discharge to its natural location, Little Bear Creek. The Unocal site lies next to Puget Sound, and it is proposed to discharge treated stormwater from that site into the Sound.

MR #5, Onsite Stormwater Management – This calls for onsite retention of stormwater to the extent feasible. Low-impact development (LID) features and retention and establishment of forest cover, where feasible, will be strong features of Brightwater. These are explained in more detail in the discussions of the various alternatives later in this memorandum.

MR #6, Runoff Treatment – Water quality treatment must be provided for all impervious and pervious pollutant-generating surfaces. Stormwater quality treatment must be sized to accommodate the runoff from the 6-month, 24-hour storm.

MR #7, Flow Control – The post-project stormwater discharges must match the flow durations of the site under predeveloped conditions for discharge rates ranging from one-half of the peak, 2-year flow up to the peak 50-year flow. The predeveloped condition is defined to be undisturbed forested land, which is the presumed natural cover for all land in Western Washington prior to development. Flow control is not needed if the stormwater is piped to marine water or to certain large lakes or rivers. MR # 7 was used to size stormwater detention ponds for the project.

MR #8, Wetlands Protection – Natural wetlands must be protected from excessive flow fluctuation and water quality impacts resulting from stormwater discharges. King County does not anticipate using any existing wetlands for either detention or water quality treatment of Brightwater-related stormwater. However, if any release of treated and detained stormwater to a natural wetland should be proposed during the permitting process, it would be designed to meet the hydro-period requirements of MR #8.

MR #9, Basin Planning – Not applicable. Neither project site lies within an area that has a basin plan.

MR #10, Stormwater Facility Operation and Maintenance – This will apply during a later stage of the project.

Other stormwater-related regulations are reviewed in Appendix 6-C, Management of Water Quality During Construction at the Treatment Plant Sites.

1.2 Modeling Methods

Stormwater runoff from the project sites and the associated detention requirements were calculated using Ecology's Western Washington Hydrological Model, Version 2). This model simulates a continuous flow record using historical rainfall data for the project area. Synthetic flow records are produced for both the predeveloped condition and the post-project condition. For the detention calculations, the predeveloped condition is assumed to be undisturbed forest per the Ecology Manual.

Stormwater treatment requirements were calculated for the pollutant-generating surfaces at the treatment plant. These surfaces include roads, parking areas, and other hard-surface areas around the facilities. They so not include roofs, forested areas, or landscaped areas (the latter will be operated as low fertilizer/pesticide use under an approved landscape management plan). The treatment volume was calculated for the 6-month, 24-hour storm event for the post-project site conditions, per the Ecology Manual. A single-event model called StormShed was used to calculate the runoff volume from that event. StormShed uses the Santa Barbara Unit Hydrograph Method to develop the hydrograph representing stormwater runoff resulting from a rainfall distribution input to the model. In accordance with the Ecology Manual, the 6-month, 24-hour rainfall amount was taken as 72 percent of the 2-year, 24-hour rainfall amount at each project site.

Figures at the end of this memorandum show the project layouts used to model the post-project conditions at each site. The stormwater facilities shown in the figures, while scaled to provide the needed volumes, are conceptual in nature. The specific sizing and drainage layout for the individual stormwater facilities will be developed in the design phase of the project and submitted for review and approval by the permitting agencies.

1.3 Source Control in Lieu of Enhanced Treatment

The Ecology Manual specifies enhanced treatment for stormwater runoff from industrial sites such as the Brightwater plant. Runoff from industrial areas can contain contaminants related to site operations or resulting from chemical spills or other losses of process materials. Enhanced stormwater treatment typically consists of two separate stormwater facilities connected in series, such as a stormwater pond followed by sand filtration. This enhanced level of treatment is intended to more effectively remove contaminants that may enter the runoff from the site prior to discharge.

For Brightwater, contaminated runoff could occur at certain process locations such as chemical storage areas, chemical transfer locations, biosolids truck loading areas, and truck parking or maintenance areas. Material removal from the grit chamber at the headworks and the fine screens at the primary clarifiers presents another potential for spillage of contaminated material. The project will be designed to hydraulically isolate exposed ground surfaces surrounding these areas so that local runoff does not mix with stormwater from other parts of the site. Instead, the runoff from these isolated locations will either flow to a designated sump or be routed to the treatment plant, where it will be fully treated and discharged in the effluent line. These comprehensive source control methods will greatly reduce, if not entirely eliminate, the potential that contaminants from the wastewater treatment process could enter the stormwater system. The project design will be closely coordinated with Ecology and the local permitting agency to determine the appropriate reduction or possible elimination of the need for enhanced stormwater treatment.

Landscaping at the plant site will emphasize the use of native and other low-maintenance plantings. Maintenance plans will be developed to ensure minimal use of fertilizers, herbicides, and pesticides. The landscaped areas will therefore not be considered pollutant-generating pervious surfaces (PGPS) and will not require water quality treatment.

1.4 Low-Impact Development (LID)

As part of Brightwater's commitment to high sustainability, LID measures will be used extensively wherever feasible. Instead of relying solely on engineered piping systems, LID emphasizes decentralized stormwater management using vegetation and infiltration to reduce the runoff quantity and flow rate. LID has the additional advantage of reducing stormwater runoff and therefore reducing the required size of the stormwater facilities. The LID approaches that can be applied to this project include open site design, vegetation planting, vegetated roof, pervious pavement, bioretention swales, and amended soil. These approaches are discussed below.

<u>Open site design</u>. The project site design will minimize the impervious surface area while maximizing open vegetated space. This concept is referred to as “open site design” and is an important element in developing the site layout for this project. The vegetated area will be located downslope, if feasible, from the building sites. Flow control and water quality will be enhanced by flow dispersion through mulched areas and vegetation.

<u>Vegetation planting</u>. Planted trees and shrubs and/or landscaping areas within the project site can retain more stormwater onsite and reduce the stormwater runoff into the drainage system.

<u>Vegetated roofs</u>. Also known as green roofs, these can be used on some of the buildings. Green roofs greatly reduce runoff rates, providing natural detention and retention of rainfall. Buildings with green roofs will be provided with adequate structural support for the additional weight on the roof.

<u>Pervious Pavement</u>. Using pervious pavement for parking areas, light-use roadways, and sidewalks can promote stormwater retention and infiltration, thus greatly reducing runoff from these areas. The infiltration rate depends on the nature of the soil and the depth to groundwater. Further site study would be necessary to determine the feasibility of pervious pavement once the specific location of project facilities is finalized.

<u>Bioretention swales</u>. Low spots in the site topography can be retained, enhanced, or created to hold stormwater and release it slowly into the drainage channels. Cattails, reeds, and other typical wetland plants would increase the retention capacity.

<u>Amended soils</u>. The use of amended soil in all reforested and landscaped areas and the biofilter area can increase stormwater retention within the soil. Runoff from roof

downspouts and paved areas can be conveyed into these landscaped areas to use the water-holding capacity of the soil.

Maximizing onsite stormwater retention through LID strategies will reduce the runoff, improve its quality, and reduce the required size of stormwater detention and treatment facilities. While many agencies in western Washington encourage the use of LID, it is important to work closely with the agencies to ensure their agreement with the LID measures adopted at the project site, particularly the amount of reduction in required detention.

For purposes of the Environmental Impact Statement (EIS), no reduction in runoff or detention from LID implementation is assumed.

2 ROUTE 9 SITE

The 114.3-acre Route 9 site has forest and wetlands at its north end, and southern half is occupied by several large auto yards and other commercial activities. The central part is cleared land containing several industrial buildings. This site drains to Little Bear Creek, which lies a short distance to the west across State Route 9 (SR-9). More information on Little Bear Creek can be found in Chapter 6 of the EIS.

2.1 Offsite Flows

Numerous small streams and watercourses flow across the site (Figure 1). Howell Creek lies at the south side, and an unnamed stream ("Unnamed Creek") is located at the north side. Between these two streams (moving from south to north) are Watercourses 1 through 8, Channel A, and Channel B (also known as 228th Street Creek). They flow across the site in a series of pipes and open ditches, discharging to the SR-9 drainage system along the west side of the site. Runoff in this drainage system crosses under SR-9 through one of four culverts and then discharges to Little Bear Creek.

Because construction at this site would require extensive regrading over a period of years, it would be difficult to protect the quality of these watercourses if they were flowing across the site. In addition, the treatment plant would have a number of large pipes and a major north-south canal crossing the path of these watercourses. Because of the intensive development of project facilities, maintaining even minimal buffer widths would be problematic. Thus it would be necessary to divert these watercourses north or south around the east side of the site. It is proposed to combine them into just two relocated channels because they have low flows, a number of them are dry for long periods, and the total area of all of these drainages is just 257 acres. The two-channel layout offers a better opportunity for stream and habitat restoration, which would be concentrated at the north and south ends of the site.

Watercourses 1 through 8 would be diverted south to Howell Creek. They would likely be piped for part of the route because of the steep terrain and limited space available along the east side of the site. As the diverted watercourses combined and approached the southern side of the site, beyond the stormwater treatment facilities, the relocated stream would be daylighted, turned west, and merged into Howell Creek, which would continue to flow through an existing culvert under SR-9. This culvert, however, would likely need rebuilding because it does not appear to have the capacity for the increased flow.

Channels A and B would be diverted north around the treatment facilities to a wetland mitigation area proposed for the north side of the site. There would then be no offsite flows entering the site. Unnamed Creek lies north of the plant area and would not be affected by project construction; its channel, however, may be diverted to join with Channels A and B in a combined stream restoration. Stream relocation is discussed further in Chapter 6 of the EIS.

2.2 Model Input

In modeling the Route 9 site, it was assigned various cover types as summarized in Table 1. The soil condition was assumed to be Till because much of the site is known to have a high water table. The predeveloped site runoff condition was modeled as Till-Forest cover. All roofs, sidewalks, roads, parking areas, and stormwater facilities were modeled as impervious areas. The proposed canal, stormwater detention facilities, and swales would have water in them and were also modeled as impervious areas. The areas proposed for forest establishment were modeled as Till-Pasture. These areas would be established with amended soils and over time would function as forest from a hydrologic standpoint. Because of the time delay in achieving forest function, the higher runoff-producing Pasture designation would more realistically simulate runoff conditions in the initial operations period. Areas of the site identified for landscaping were modeled as Till-Landscape.

TABLE 1
Basic Stormwater Model Inputs for the Route 9 Site

Soil Cover	Area[a] (acres)	Modeled as / CN[b]	Detention Volume Required (acre-ft)	Treatment Volume Required (acre-ft)
Forest	21.5	Pasture /74	2.1	NA
Landscape	6.2	Landscape /86	1.2	NA
Pond, swale, canal	9.6	Impervious /100	4.8	1.0
Roofs	9.4	Impervious /98	4.8	NA
Roadways	8.3	Impervious /98	4.4	0.8
Future expansion	8.9	Impervious /98	4.7	0.9
Total	**63.9**		**22**	**2.7**

[a] These are acreages at full project buildout. The Future Expansion Area would initially be forested.
[b] CN = curve number. StormShed uses these values to generate the water quality treatment volume.

Runoff from pollutant-generating surfaces requires treatment. These surfaces include roadways, parking lots, sidewalks, and other unroofed, impervious areas of the treatment plant that drain to the stormwater system. Runoff from the future expansion area would also require water quality treatment. Although the stormwater ponds, swales, and canal do not generate pollutants, volume must be added to account for the rainfall that falls directly on these surfaces. Low-maintenance practices will be used on the landscape, and its runoff will not require water quality treatment (see Section 1.3).

Table 1 summarizes the input for this model. The model output for the Route 9 site is shown in Attachment A. A total of 22 acre-feet of detention volume is calculated for the Route 9 site. In addition, 2.7 acre-feet of water quality treatment volume would be needed.

2.3 Major Stormwater Facilities

The stormwater system will serve the central 64-acre portion of the Route 9 site. As shown in Figure 2, the south and north ends of the site will be natural areas, primarily forest and created/restored wetlands. These areas will have no stormwater system.

The project concept calls for restoring 22 acres, or about one-third of the 64 acres served by the stormwater system, to forest cover. This acreage will eventually mimic the natural hydrologic processes of the site in its predeveloped, forested state. This forested area may also be used to disperse some of the stormwater generated by adjacent built areas of the plant.

Impervious areas (excluding stormwater facilities) will cover 27 acres, or about 42 percent of the 64-acre stormwater management area. This includes 9 acres of potential plant expansion area that will initially be planted in forest cover. For purposes of calculating stormwater management requirements, this 9 acres was assumed to be impervious area.

Figure 3 is a conceptual layout of the stormwater management system. The canal that runs the full length of the site, north to south, is a central architectural feature and would also provide stormwater management. This canal would be about 60 feet wide and would provide 3 vertical feet of detention storage across two-thirds of that width (Figure 4). It would provide approximately 8 acre-feet of detention storage and would receive runoff from roofs, landscaped areas, and other non-pollutant-generating areas of the site. The canal may also receive stormwater runoff that has been treated at other stormwater management facilities onsite. The canal may be divided into several discrete detention units, discharging at multiple locations.

Some underground piping or vaults may be used to provide approximately 3 acre-feet of detention within or immediately next to the built areas of the plant, east of the canal. The remaining detention will be provided by a series of linear ponds and constructed wetlands along the western side of the site. Together these will provide about 13 acre-feet of detention. Stormwater from the treatment plant roads, parking areas, and other pollutant-generating surfaces will be conveyed to this area for treatment and detention. Overall, approximately 24 acre-feet of detention can be provided. This is more than adequate to accommodate the 22 acre-feet of required detention shown in Table 1.

LID measures are not explicitly factored into the stormwater concept at this stage, but are expected to play an important role in reducing the runoff that needs to be handled. The feasibility of installing green roofs will be explored for the Administration Center, Community-Oriented Building, Maintenance Building, and influent and reuse pump stations. Pervious pavement will be considered for those secondary roads and parking lots where seasonally high groundwater levels do not occur. Bioretention swales will be designed into the landscaped areas and along the edges of selected forested areas.

2.4 Discharge to Little Bear Creek

Discharge from the Route 9 site will be through at least three culverts, north to south, into Little Bear Creek as illustrated in Figure 3. Enroute, following detention and treatment, stormwater would be released to a series of wide, shallow swales. There is ample room for these swales in the proposed forested area downgradient from the detention areas, since the only project features in the western part of the site are the Community-Oriented Building and its parking lot. For simplicity, Figure 3 shows only a few single swales. It is anticipated that the detailed design will produce a series of intermingling swales, achieving a more natural character for the area. This allows for some additional treatment and infiltration of the treated stormwater. The swales would discharge to existing culverts under SR-9. This scheme would generally preserve the existing distribution of runoff from the site to the creek.

The treatment received in the stormwater ponds and swales would produce stormwater that is low in suspended sediments, oil and grease, and other pollutants potentially generated at the plant site. This treatment ensures protection of the water quality in Little Bear Creek. In fact, the quality downstream, where runoff from large commercial and industrial areas currently receives no treatment, is expected to improve. There is a potential that the creek—which currently does not meet temperature standards—could be warmed by runoff that is heated in the ponds on warm, sunny days. To minimize this potential, the ponds would be designed in a narrow configuration and oriented north-south. Trees planted along the west side of the ponds and along the swales would provide shade and minimize solar heating of the water. Further information on measures to minimize thermal impact from stormwater treatment can be found in Appendix 6-J, Summer Season Temperature Effects of Stormwater Ponds on Receiving Streams.

2.5 Dewatering

The depth to groundwater at the Route 9 site is 5 feet or less at some locations. Many of the project facilities will be constructed well below ground level and will require a dewatering system to control groundwater levels. During construction, dewatering wells will be used to lower the groundwater sufficiently to construct individual facilities. As each facility is constructed, a gravity subdrain under the base of the facility will provide permanent dewatering. As individual facilities are completed, the total amount of dewatering flow will gradually increase. Dewatering quantities and handling during construction are discussed in Appendix 6-C, Management of Water Quality During Construction at the Treatment Plant Sites.

Following construction completion, the rate of dewatering flow generated at the project site is estimated to be 350 gallons per minute (gpm), or 0.8 cubic feet per second (cfs) (Appendix 6-B, Geology and Groundwater). Future development of the site to its ultimate capacity would double this dewatering flow to 700 gpm (1.6 cfs). All dewatering flows would be collected and conveyed through the site in a series of separate drain pipes. This water would be conveyed downgradient from the stormwater detention facilities and discharged to the stormwater swales. From there, the water would mix with the stormwater released from the site. This commingled water may seep into the ground and/or flow to the culverts under SR-9 and then to Little Bear Creek. Like the stormwater releases discussed above, it would flow into Little Bear Creek at a number of locations, north and south, along the length of the site. This would closely mimic the distributed, natural flow path that the intercepted groundwater would follow under natural conditions.

Groundwater in the shallow aquifer underlying the site moves toward and discharges to Little Bear Creek (Appendix 6-B, Geology and Groundwater). The subdrains would intercept this groundwater and continue to direct it to Little Bear Creek. Therefore, the long-term effect of the subdrain system on flows in Little Bear Creek would be minimal. The short-term effects of dewatering discharge to Little Bear Creek are discussed in Appendix 6-C, Management of Water Quality During Construction at the Treatment Plant Sites.

Based on regional groundwater quality data (Table 2), the quality of this water is expected to be good. The water would be suitable for discharge without further treatment, with one exception: the dissolved oxygen levels would likely be low, possibly less than 1 milligram per liter (mg/L), whereas the state standard for Little Bear Creek is 9.5 mg/L. The dissolved oxygen levels in the subdrain can be raised sufficiently by designing several small vertical drops to allow aeration of the flow to near-saturation levels (on the order of 10 mg/L) of dissolved oxygen prior to discharge.

The subdrain dewatering system could be vulnerable to leaks from the overlying facilities. Although unlikely to occur, leakage from process tanks or pipes could find its way into the drains and be conveyed away in the pipe system. It is recommended that each of the major subdrain pipes be monitored periodically for wastewater/effluent parameters such as coliform, phosphorus, ammonia, and chloride.

3 UNOCAL SITE

The 52.6-acre Unocal site was formerly used to store petroleum products. The storage tanks have all been removed. This site drains to Willow Creek, and Puget Sound lies a short distance to the west. More information on Willow Creek and Puget Sound can be found in Chapter 6 of the EIS.

3.1 Offsite Flows

The project site encompasses the northern third of a small hill and a level area at the foot of the hill. There is no offsite flow onto the project site.

3.2 Model Input

Stormwater detention is not needed for the Unocal site (see Section 3.3). The StormShed model was run to generate the required water quality treatment volume; the input for this model is summarized in Table 3. Although the stormwater pond does not generate pollutants itself, volume must be added to account for the rainfall that falls directly on the pond surface. Low-maintenance practices will be used on the landscape, and its runoff will not require water quality treatment (see Section 1.3).

TABLE 2
Regional Groundwater Quality Data

Common Constituent or Property	Geohydrologic Unit (number of samples)						
	Qal (13)	**Qvr (26)**	**Qvt (39)**	**Qva (139)**	**Qtb (13)**	**Qu (31)**	**Tb (36)**
pH, field (standard units)	6.6	6.2	7.5	7.7	8.0	8.0	8.5
Dissolved oxygen, field (mg/L)	1.4	5.2	0.6	0.8[a]	<0.1	0.1[b]	0.1
Specific conductance, field (µS/cm)	121	160	197	185	231	250	399
Temperature, field (°C)	12	12	12	11	10.5	11.5	11.2
Fecal coliform, field (cols/100 mL)	<1	<1	<1	<1	<1	<1	<1
Hardness (mg/L as $CaCO_3$)	51	48	70	71	70	81	21
Calcium (mg/L)	11	12	17	15	15	16	6.0
Magnesium (mg/L)	5.5	3.6	7.1	7.4	6.9	9.6	2.0
Sodium (mg/L)	3.6	4.7	5.9	6.3	10	14	61
Potassium (mg/L)	1.6	1.4	1.7	1.9	3.0	2.3	.7
Alkalinity, laboratory (mg/L as $CaCO_3$)	56	40	77	77	107	113	164
Sulfate (mg/L)	3.1	4.2	6.0	5.0	1.2	4.4	4.5
Chloride (mg/L)	2.3	3.1	2.9	3.3	3.2	5.4	3.3
Fluoride (mg/L)	0.1	<0.1	0.1	0.1	0.2	0.1	0.2
Silica (mg/L)	19	20	27	30	31	36	16
Dissolved solids (mg/L)	80	103	123[c]	124[d]	156[e]	158[f]	257[g]
Nitrite (mg/L as N)	<01	<01	<01	<01	<01	<01	<01
Nitrate (mg/L as N)	0.27	0.59	<0.05	-10	<0.05	<0.05	<0.05
Ammonia (mg/L as N)	0.03	<0.03	0.04	0.04	0.21	0.28	0.08
Phosphorus (mg/L)	0.03	0.01	0.06	0.08	0.28	0.23	0.09
Arsenic (µg/L)	<1	<1	2[c]	3	6	2	<1
Iron (µg/L)	43	14	40	38	130	220	26
Manganese (µg/L)	31	3	43	31	79	70	5.5
Trace Element	**Qal (1)**	**Qvr (50)**	**Qvt (8)**	**Qva (23)**	**Qtb (5)**	**Qu (12)**	**Tb (14)**
Barium (µg/L)	--	22	16	14	20	22	26
Cadmium (µg/L)	--	<1	<1	<1	<1	<1	<1
Chromium (µg/L)	0	<1	<1	<1	<1	<1	<1
Copper (µg/L)	--	<1	<1	<1	<1	<1	<1
Lead (µg/L)	--	<1	<1	<1	<1	<1	<1
Mercury (µg/L)	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium (µg/L)	--	<1	<1	<1	<1	<1	<1
Silver (µg/L)	--	<1	<1	<1	<1	<1	<1
Zinc (µg/L)	--	6	9.5	20	7	74.5	4.5
Septage-Related Compound	**Qal (7)**	**Qvr (12)**	**Qvt (18)**	**Qva (44)**	**Qtb (3)**	**Qu (4)**	**Tb (6)**
Boron (µg/L)	20	10	10	10	40	25	280
Dissolved organic carbon (mg/L)	0.7	0.6	0.4	0.3[h]	--	1.3	0.5[i]
Methylene-blue-active substances (mg/L)	<0.02	<0.02	<.02[j]	<0.02	--	<0.02	<0.02

n = number of samples:

[a]n=138; [b]n=29; [c]n=38; [d]n=135; [e]n=10; [f]n=24; [g]n=30; [h]n=47; [i]n=7; [j]n=19.

Concentrations are dissolved; mg/L = milligrams per liter; µg/L = micrograms per liter; °C = degrees Celsius; µS/cm = microsiemens per centimeter at 25°C; $CaCO_3$ = calcium carbonate; N = nitrogen; -- = no value; Qal = alluvium; Qvr = Vashon recessional outwash; Qvt = Vashon till; Qva = Vashon advance outwash; Qtb = transitional beds; Qu = undifferentiated sediments; Tb = bedrock.

Source: Thomas et al., 1997

TABLE 3
Water Quality Treatment Hydrological Model Input

Cover (Proposed Condition) / CN[a]	Area (acres)	Treatment Volume Required (acre-feet)
Landscape / 86	19.7	NA
Impervious / 98	27.4	2.8
Pond / 100	1	0.1
Total	**48.1**	**2.9**

[a] CN = curve number. StormShed uses these values to generate the water quality treatment volume.

The model output for the Unocal site is shown in Attachment B. A total of 2.9 acre-feet of water quality treatment would be needed.

3.3 Stormwater Facilities

A conceptual layout of the Unocal site is shown in Figure 5. After treatment in a stormwater pond, runoff from the project site can be discharged via a pipeline to Puget Sound, a marine water body. As a result, no stormwater detention would be required (refer to Minimum Requirement #7 of the Ecology Manual).

The primary stormwater facility for the Unocal site would be a single large water quality treatment pond in the northwest part of the site. The pond would be about 500 feet long and 130 feet wide, covering 1.5 acres.

Much of the Unocal site is proposed for a new multimodal transportation facility, the Edmonds Crossing project (Bernstein/WSA, 1995), which involves relocation of the Edmonds Ferry Terminal. To co-locate the Brightwater treatment plant and the Edmonds Crossing project, most of the treatment facilities would be covered with a structural lid. A portion of the Edmonds Crossing project would then be constructed on top of this lid. The conceptual layout is shown in Figure 6. For purposes of calculating runoff at the Unocal site (see Section 3.2), it is assumed that the combined project (Edmonds Crossing and Brightwater) will be built.

Should this project proceed at the Unocal site, particularly if co-located with Edmonds Crossing, the water quality treatment facility would require additional analysis. Nearly all of the part of Edmonds Crossing overlying the treatment plant site would consist of a large parking lot and ferry auto traffic and bus holding lanes. These surfaces could be expected to accumulate substantial quantities of sediment, oil and grease, and related motor vehicle pollutants. It is recommended that this runoff undergo oil-water separation or similar pretreatment prior to its delivery to the water quality treatment pond. From a structural standpoint, one or more water quality vaults might prove more practical to construct than an open water quality treatment pond.

3.4 Discharge to Puget Sound

The treated stormwater would be piped into Puget Sound, avoiding the need for detention. The highest tides in this area reach 14.2 feet above mean lower low water (MLLW). The stormwater quality pond would discharge above that elevation to prevent possible inflow of brackish water at the highest tides. Several options exist for conveying the treated stormwater to Puget Sound. The use of the treatment plant outfall was considered, but was eliminated because it was found that there was insufficient head for the stormwater discharge to enter the effluent outfall.

Runoff from most of the site currently flows into Willow Creek, which flows along the eastern, northern, and western perimeters of the Unocal site. Once it leaves the site, Willow Creek is conveyed to Puget Sound through a 42-inch pipe. If the Unocal site is selected, the creek will be diverted from the pipe and moved to an open stream channel flowing into Puget Sound (see Chapter 6). This pipe would then be available to convey the discharge from the stormwater pond.

Another option would be to construct a second outfall from the plant, specifically to convey stormwater. This outfall would be constructed in the same trench as the larger effluent outfall. The two pipes would emerge from the trench at a depth of -50 feet MLLW in Puget Sound, nearly 1,000 feet offshore. The stormwater pipe would discharge at this point.

A dilution analysis of this marine discharge was performed and is included in Attachment C. It was shown that a discharge at 15 feet MLLW would require a 48-inch-diameter outfall pipe. The outfall would achieve a minimum dilution of 19:1 within the mixing zone. Dilution at the shoreline, the area most likely to involve human contact, would be considerably more. When compared to the shoreline discharge option, the marine discharge option would provide far more dilution of the treated runoff, possibly by as much as a factor of 10.

3.5 Dewatering

The major project facilities in the lower portion of the Unocal site will be supported by pile foundations. These pile foundations would be designed to handle the hydrostatic uplift pressures during the life of the facility. Therefore, no dewatering is anticipated during project operation.

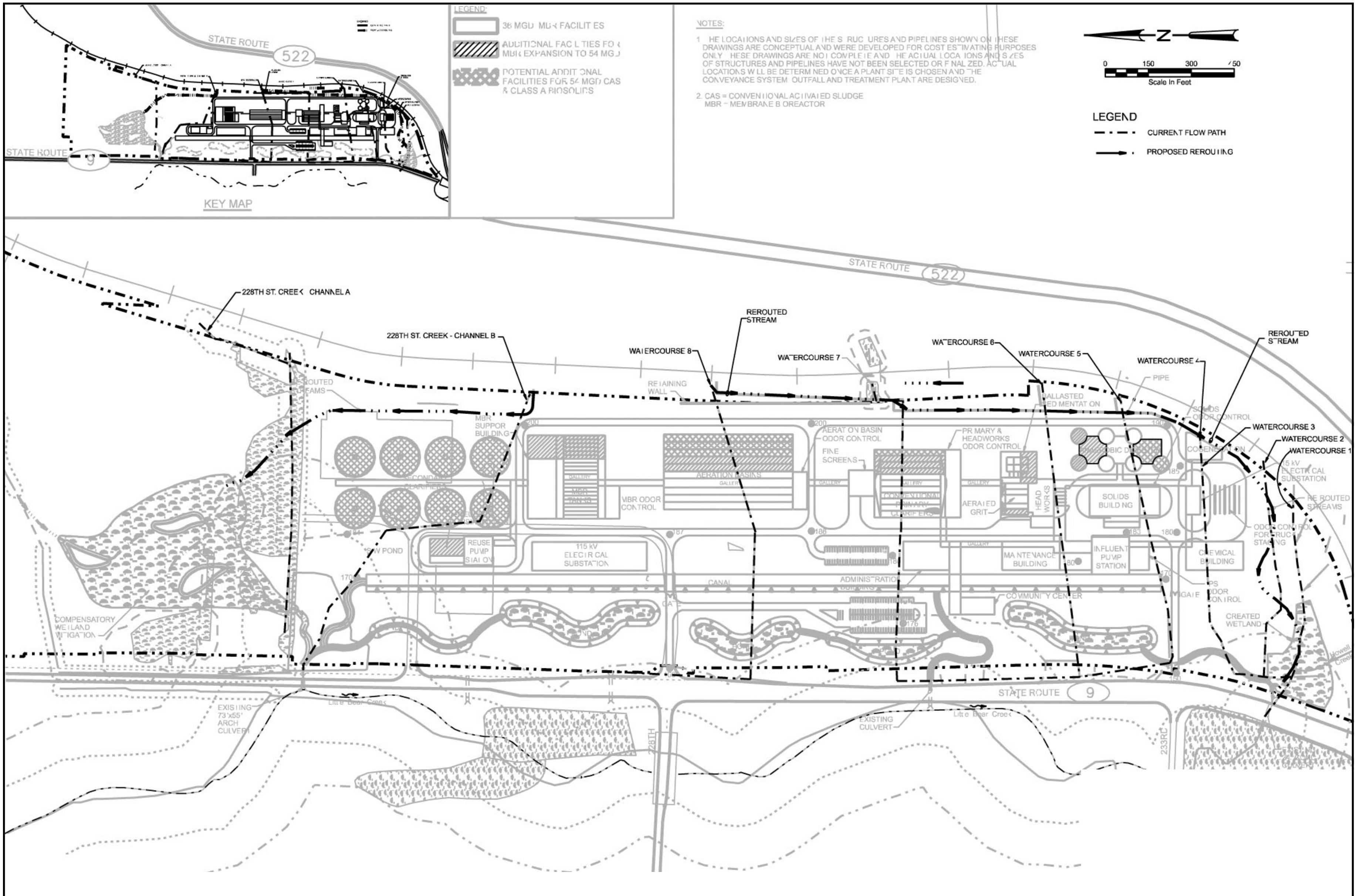
4 REFERENCES

Bernstein, P.E./Wilbur Smith Associates. 1995. *Edmonds Crossing Project Discipline Report*. Prepared for Federal Highway Administration, WSDOT, and City of Edmonds. Prepared by Reid Middleton, Inc., submitted by CH2M HILL, Bellevue, WA. 1995.

Ecology. 2001. *Stormwater Management Manual for Western Washington*. Washington State Department of Ecology, Lacey, WA.

Thomas, B.E.; J.M. Wilkinson; and S.S. Embrey. 1997. *The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington*. Water Resources Investigations Report 96-4312. U.S. Geological Survey.

COE, 2000. Tidal Datum Regions, North Puget Sound Region 96 – Edmonds. U.S. Army Corps of Engineers. Web site: http://www.nwd-wc.usace.army.mil/nws/hh/tides/np/np96.htm



King County

Department of
Natural Resources and Parks

Wastewater Treatment Division

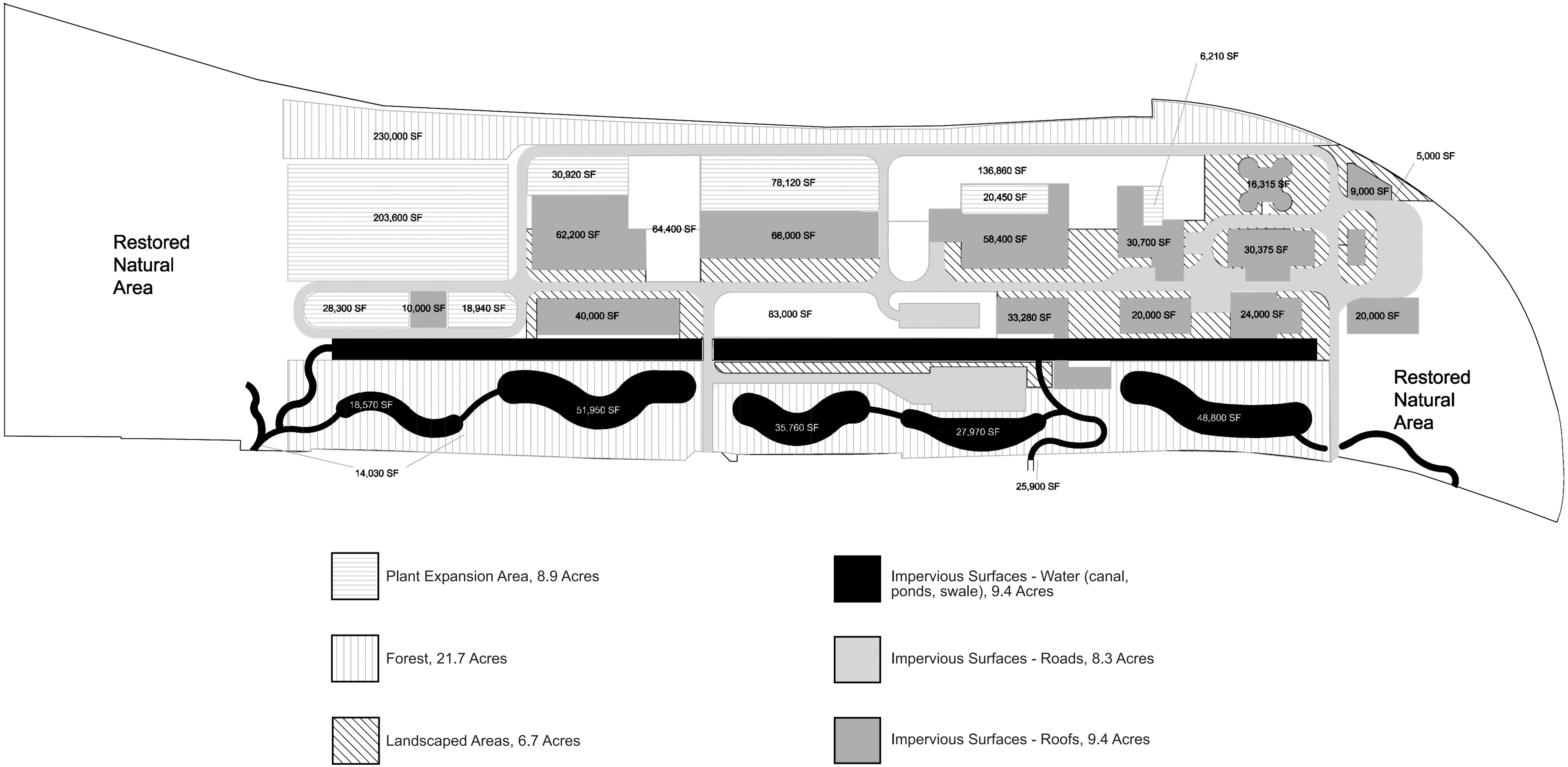
Prepared by: CH2M HILL

File Name: 176493.03.06_W052003009SEA_Stormwater TM • Fig 1 Streams Flowing Across the Route 9 Site • 7/18/03 • dk/lw/gr

Figure 1

Streams Flowing Across the Route 9 Site

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



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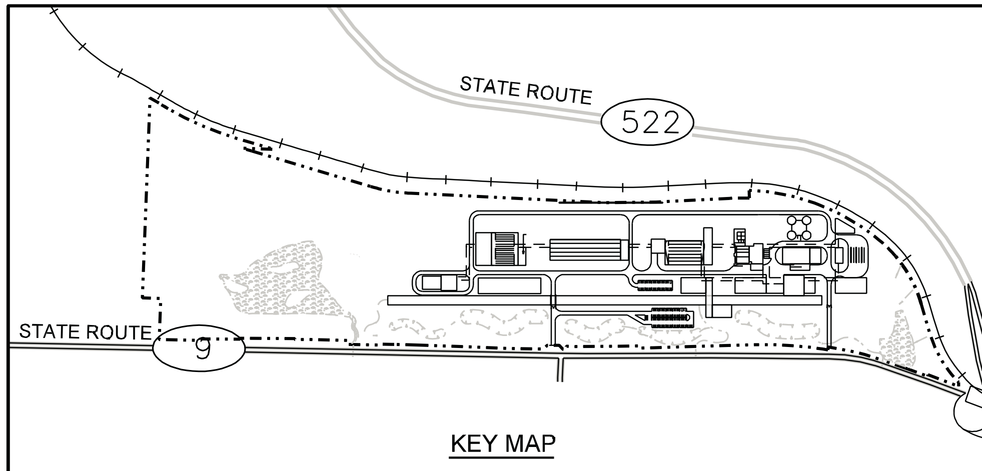
Prepared by: CH2M HILL
File Name: 176493.03.06_W052003009SEA_Stormwater TM • Fig 2 Major Cover Types - Route 9 Site • 7/18/03 • dk/gr

Figure 2
Stormwater Management Area for the Route 9 Site Showing Major Cover Types

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



LEGEND:

- 36 MGD MBR FACILITIES
- ADDITIONAL FACILITIES FOR MBR EXPANSION TO 54 MGD
- POTENTIAL ADDITIONAL FACILITIES FOR 54 MGD CAS & CLASS A BIOSOLIDS
- (X) WATER COURSE

N

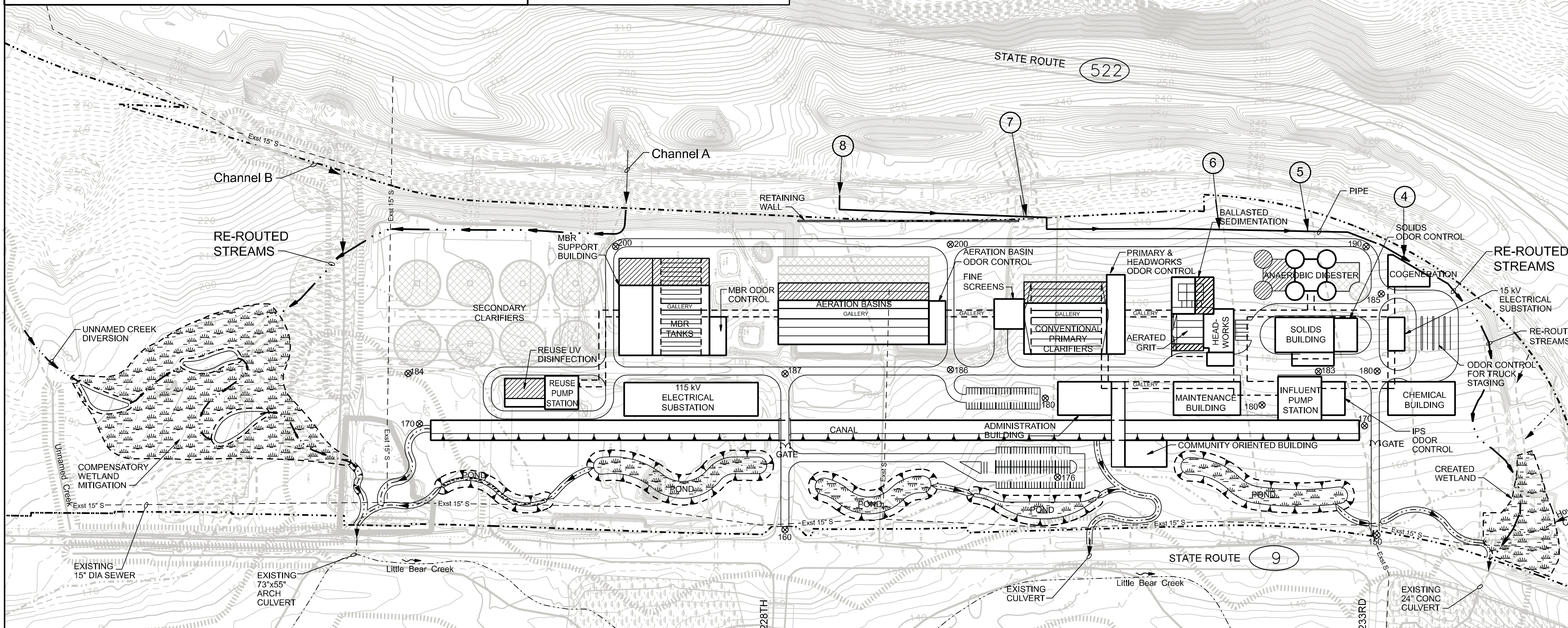
0 150 300 450 FEET

June 2003

NOTES:

1. THE LOCATIONS AND SIZES OF THE STRUCTURES AND PIPELINES SHOWN ON THESE DRAWINGS ARE CONCEPTUAL AND WERE DEVELOPED FOR COST ESTIMATING PURPOSES ONLY. THESE DRAWINGS ARE NOT COMPLETE AND THE ACTUAL LOCATIONS AND SIZES OF STRUCTURES AND PIPELINES HAVE NOT BEEN SELECTED OR FINALIZED. ACTUAL LOCATIONS WILL BE DETERMINED ONCE A PLANT SITE IS CHOSEN AND THE CONVEYANCE SYSTEM, OUTFALL AND TREATMENT PLANT ARE DESIGNED.

2. CAS = CONVENTIONAL ACTIVATED SLUDGE
MBR = MEMBRANE BIOREACTOR



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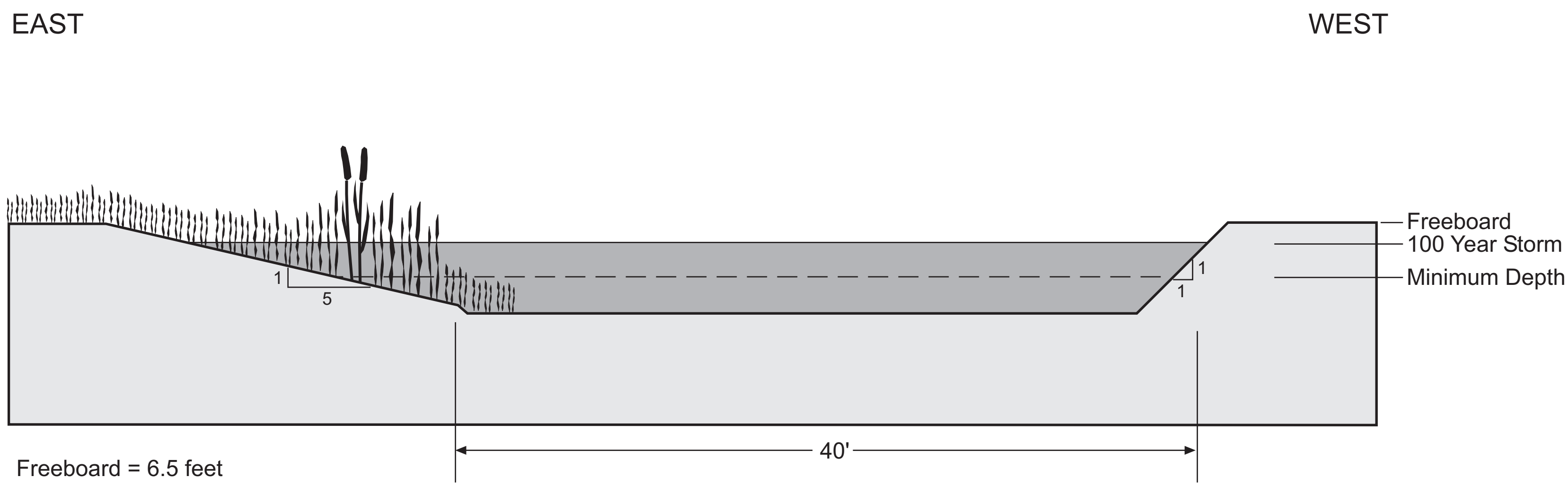
Prepared by: CH2M HILL
File Name: 176493.03.06_W052003009SEA_Stormwater TM • Fig 3 Stormwater System for Route 9 Site • 7/18/03 • dk/gr

Figure 3
Conceptual Layout of the Stormwater System for the Route 9 Site

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



Freeboard = 6.5 feet
100-year Detention = 5 feet
Minimum Depth = 2 feet

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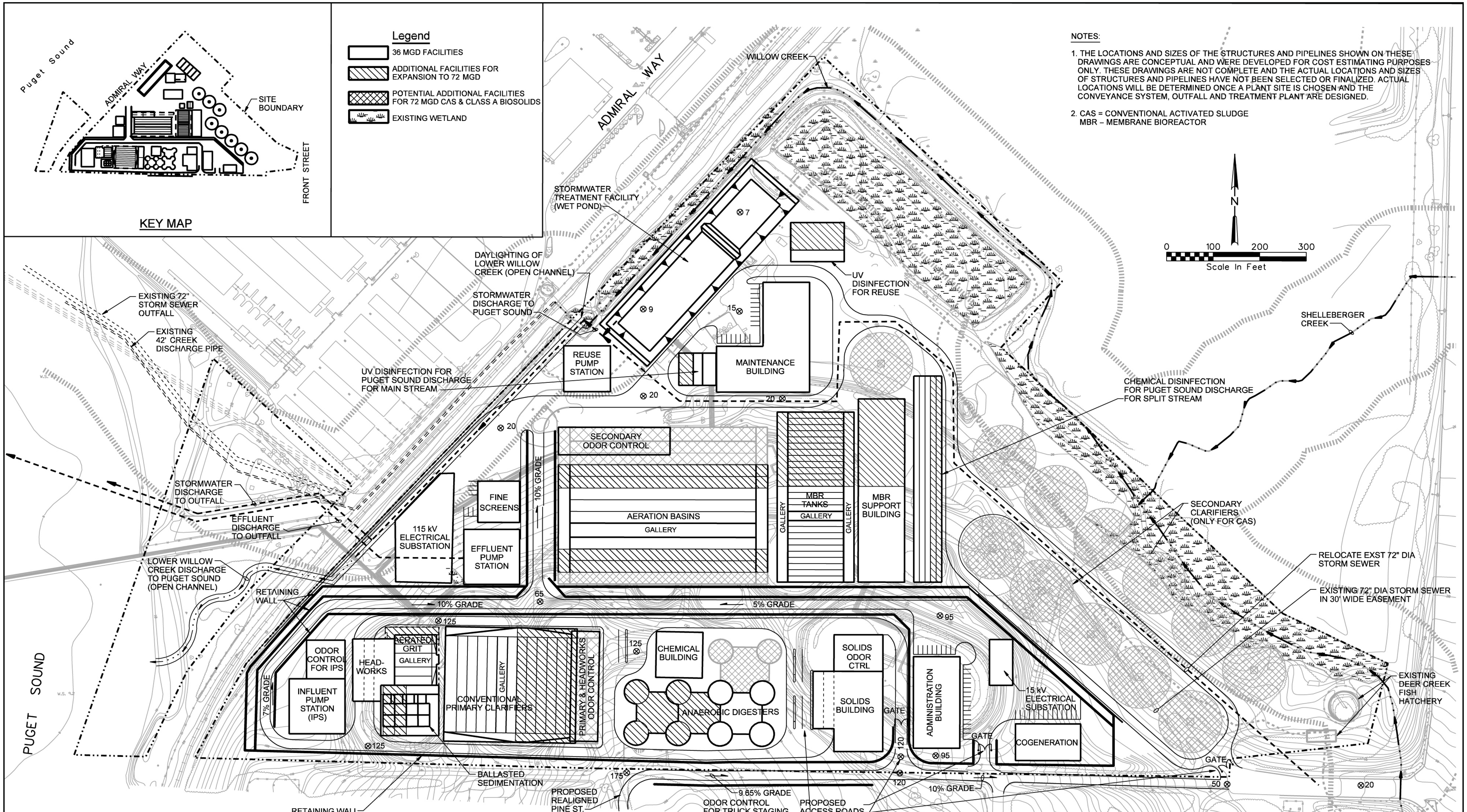
File Name: 176493.03.06_W052003009SEA_Stormwater TM • Fig 4 Cross Section of Proposed Canal • 7/18/03 • dk/gr

Figure 4
Cross-Section of the Proposed Canal

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



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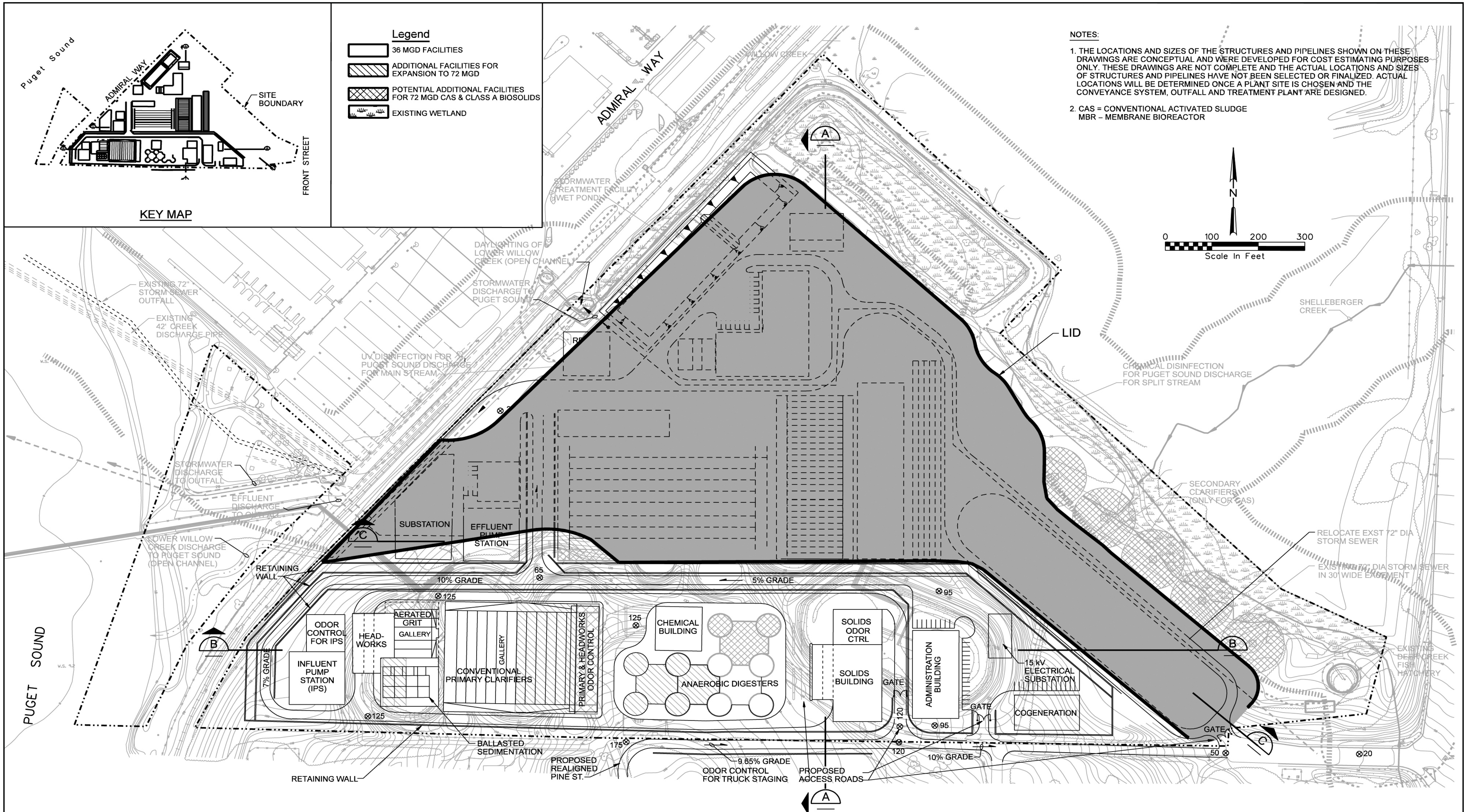
Prepared by: CH2M HILL
File Name: 176493.03.06_W052003009SEA_Stormwater TM • Fig 5 Stormwater System for Unocal Site • 7/21/03 • dk/gr

Figure 5
Conceptual Layout of the Stormwater System for the Unocal Site

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



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Prepared by: CH2M HILL
File Name: 176493.03.06_W052003009SEA_Stormwater TM • Fig 6 Edmonds Crossing and Unocal Site • 7/21/03 • dk/gr

Figure 6
The Proposed Edmonds Crossing Project Overlaid Atop the Unocal Site

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM

ATTACHMENT A - Selected Model Output for the Route 9 Site

Selected Model Output for the Route 9 Site

The detention volume was sized using the Western Washington Hydrological Model (WWHM) The detentions required for different design features (roofs, roadways, forest, landscape, future expansion, and water surfaces) was sized separately. The total detention volume required is 22 acre-feet. The water quality treatment volumes for the Route 9 site was sized on the StormShed model using the Santa Barbara Unit Hydrograph Method. The design treatment volume is 72 percent of the 2-year, 24-hour storm event. The total treatment required is 2.9 acre-feet for the site. Table 1, Basic Stormwater Model Inputs for the Route 9 Site, lists the detention required for each feature. The attached output summary is generated by WWHM with general assumptions for the pond geometry.

The water quality treatment volumes for the Route 9 site was also sized on the StormShed model using the Santa Barbara Unit Hydrograph Method. The design treatment volume is 72 percent of the 2-year, 24-hour storm event. The total treatment required is 2.7 acre-feet for the site. Table 3, Water Quality Treatment Hydrological Input, lists the treatment required. The attached output summary is generated by StormShed for the impervious surface area, pond, and future expansions.

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: Brightwater_Till Pasture LU
Site Address: Route 9
City : Woodinville
Report Date : 05/29/2003
Gage : Everett
Data Start : 1948
Data End : 1997
Precip Scale: 1.20

PREDEVELOPED LAND USE

Basin : Till Forest
Flows To : Outflow
GroundWater: No

Land Use	Acres
TILL FOREST:	21.5

DEVELOPED LAND USE
Basin : Till Pasture
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL PASTURE:	21.5

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Outflow
Dimensions
Depth: 5ft.
Bottom Length: 303.65ft.
Bottom Width : 60.72ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1 1.5
Volume at Riser Head: 2.112 acre-ft.
Discharge Structure
Riser Height: 4 ft.
Riser Diameter: 18 ft.
Orifice 1 Diameter: 3.58 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 5.59 in. **Elevation:** 2.768 ft.
Orifice 3 Diameter: 2.79 in. **Elevation:** 3.1 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.423	0.000	0.000	0.000
0.056	0.426	0.024	0.079	0.000
0.111	0.429	0.047	0.112	0.000
0.167	0.432	0.071	0.137	0.000
0.222	0.434	0.095	0.159	0.000
0.278	0.437	0.120	0.177	0.000

0.333	0.440	0.144	0.194	0.000
0.389	0.443	0.168	0.210	0.000
0.444	0.446	0.193	0.224	0.000
0.500	0.449	0.218	0.238	0.000
0.556	0.451	0.243	0.251	0.000
0.611	0.454	0.268	0.263	0.000
0.667	0.457	0.293	0.275	0.000
0.722	0.460	0.319	0.286	0.000
0.778	0.463	0.345	0.297	0.000
0.833	0.466	0.370	0.307	0.000
0.889	0.469	0.396	0.317	0.000
0.944	0.471	0.422	0.327	0.000
1.000	0.474	0.449	0.337	0.000
1.056	0.477	0.475	0.346	0.000
1.111	0.480	0.502	0.355	0.000
1.167	0.483	0.528	0.364	0.000
1.222	0.486	0.555	0.372	0.000
1.278	0.489	0.582	0.380	0.000
1.333	0.492	0.610	0.389	0.000
1.389	0.495	0.637	0.397	0.000
1.444	0.497	0.665	0.405	0.000
1.500	0.500	0.692	0.412	0.000
1.556	0.503	0.720	0.420	0.000
1.611	0.506	0.748	0.427	0.000
1.667	0.509	0.776	0.435	0.000
1.722	0.512	0.805	0.442	0.000
1.778	0.515	0.833	0.449	0.000
1.833	0.518	0.862	0.456	0.000
1.889	0.521	0.891	0.463	0.000
1.944	0.524	0.920	0.469	0.000
2.000	0.527	0.949	0.476	0.000
2.056	0.530	0.978	0.483	0.000
2.111	0.533	1.008	0.489	0.000
2.167	0.536	1.038	0.495	0.000
2.222	0.539	1.068	0.502	0.000
2.278	0.542	1.098	0.508	0.000
2.333	0.545	1.128	0.514	0.000
2.389	0.548	1.158	0.520	0.000
2.444	0.551	1.189	0.526	0.000
2.500	0.554	1.219	0.532	0.000
2.556	0.557	1.250	0.538	0.000
2.611	0.560	1.281	0.544	0.000
2.667	0.563	1.312	0.550	0.000
2.722	0.566	1.344	0.555	0.000
2.778	0.569	1.375	0.642	0.000
2.833	0.572	1.407	0.776	0.000
2.889	0.575	1.439	0.857	0.000
2.944	0.578	1.471	0.922	0.000
3.000	0.581	1.503	0.978	0.000
3.056	0.584	1.535	1.028	0.000
3.111	0.587	1.568	1.096	0.000
3.167	0.590	1.601	1.170	0.000
3.222	0.594	1.634	1.229	0.000
3.278	0.597	1.667	1.282	0.000
3.333	0.600	1.700	1.330	0.000
3.389	0.603	1.733	1.376	0.000
3.444	0.606	1.767	1.420	0.000
3.500	0.609	1.801	1.461	0.000
3.556	0.612	1.835	1.501	0.000
3.611	0.615	1.869	1.539	0.000
3.667	0.618	1.903	1.576	0.000
3.722	0.622	1.937	1.612	0.000
3.778	0.625	1.972	1.647	0.000
3.833	0.628	2.007	1.681	0.000
3.889	0.631	2.042	1.714	0.000
3.944	0.634	2.077	1.747	0.000
4.000	0.637	2.112	1.778	0.000
4.056	0.640	2.148	2.000	0.000
4.111	0.644	2.183	2.380	0.000
4.167	0.647	2.219	2.863	0.000
4.222	0.650	2.255	3.428	0.000

4.278	0.653	2.291	4.065	0.000
4.333	0.656	2.328	4.766	0.000
4.389	0.659	2.364	5.525	0.000
4.444	0.663	2.401	6.338	0.000
4.500	0.666	2.438	7.201	0.000
4.556	0.669	2.475	8.112	0.000
4.611	0.672	2.512	9.067	0.000
4.667	0.675	2.550	10.07	0.000
4.722	0.679	2.587	11.11	0.000
4.778	0.682	2.625	12.18	0.000
4.833	0.685	2.663	13.30	0.000
4.889	0.688	2.701	14.46	0.000
4.944	0.692	2.740	15.65	0.000
5.000	0.695	2.778	16.87	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	0.706
5 year	1.059
10 year	1.339
25 year	1.749
50 year	2.099
100 year	2.49

Flow Frequency Return Periods for Developed Unmitigated

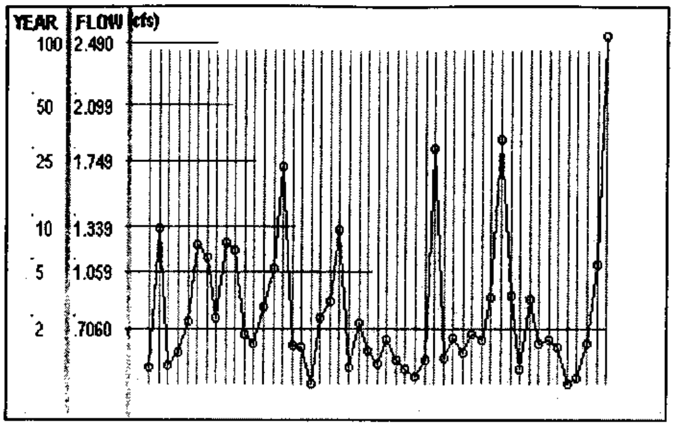
Return Period	Flow(cfs)
2 year	1.033
5 year	1.675
10 year	2.202
25 year	2.998
50 year	3.693
100 year	4.483

Flow Frequency Return Periods for Developed Mitigated

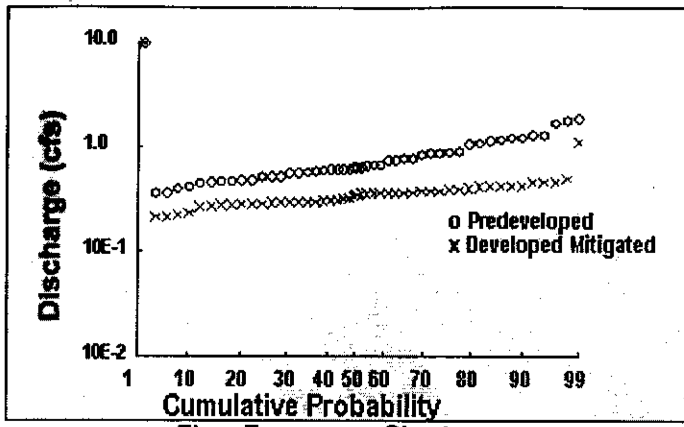
Return Period	Flow(cfs)
2 year	0.339
5 year	0.471
10 year	0.573
25 year	0.72
50 year	0.844
100 year	0.981

Yearly Peaks for Pre and Post Developed

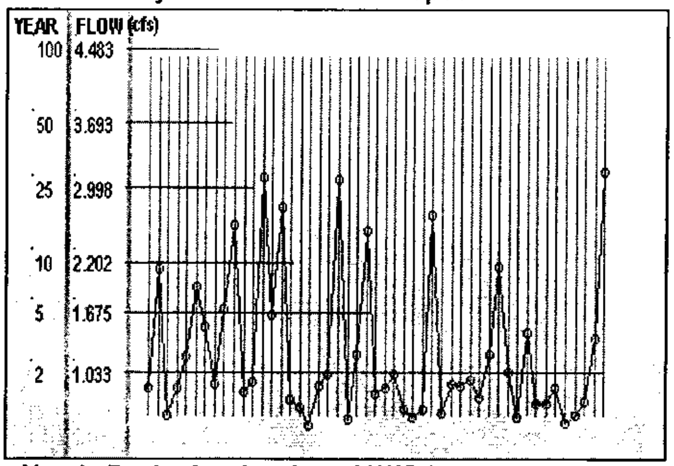
Year	Predeveloped	Developed
1949	0.470	0.266
1950	1.327	0.366
1951	0.473	0.294
1952	0.560	0.268
1953	0.754	0.214
1954	1.231	0.362
1955	1.150	0.420
1956	0.775	0.455
1957	1.243	0.459
1958	1.193	0.356
1959	0.674	0.380
1960	0.610	0.358
1961	0.843	0.361
1962	1.080	0.330
1963	1.711	0.296
1964	0.605	0.296
1965	0.591	0.374
1966	0.362	0.221
1967	0.776	0.350
1968	0.873	0.422



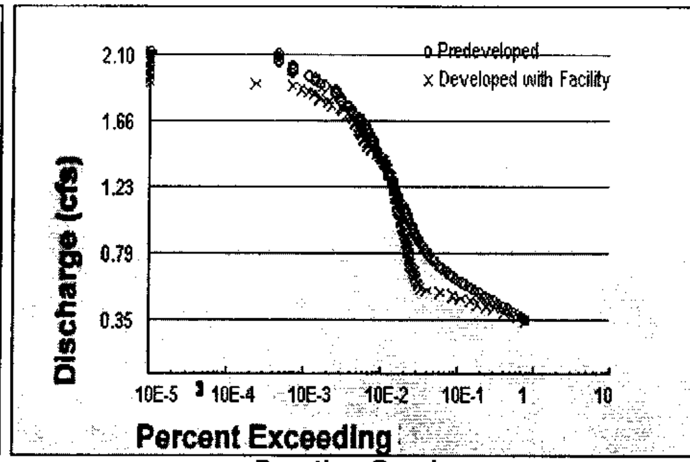
Yearly Peaks for Predeveloped



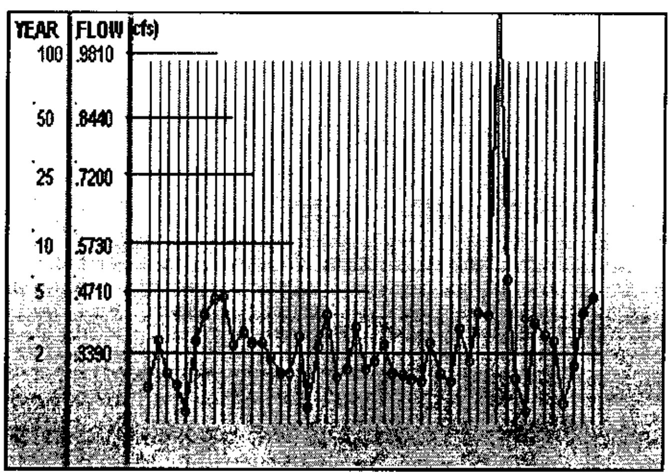
Flow Frequency Chart



Yearly Peaks for developed W/O Pond



Duration Graph



Yearly Peaks for Developed W/Pond

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: Brightwater_Landscaped LU
Site Address: Route 9
City : Woodinville
Report Date : 05/29/2003
Gage : Everett
Data Start : 1948
Data End : 1997
Precip Scale: 1.20

PREDEVELOPED LAND USE

Basin : Till Forest
Flows To : Outflow
GroundWater: No

Land Use	Acres
TILL FOREST:	6.2

DEVELOPED LAND USE
Basin : Landscaped Area
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL GRASS:	6.2

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Outflow
Dimensions
Depth: 5ft.
Bottom Length: 225ft.
Bottom Width : 43.46ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 1.211 acre-ft.
Discharge Structure
Riser Height: 4 ft.
Riser Diameter: 18 ft.
Orifice 1 Diameter: 1.71 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 2.2 in. **Elevation:** 2.4 ft.
Orifice 3 Diameter: 3 in. **Elevation:** 3.5 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.224	0.000	0.000	0.000
0.056	0.227	0.013	0.018	0.000
0.111	0.229	0.025	0.026	0.000
0.167	0.231	0.038	0.031	0.000
0.222	0.233	0.051	0.036	0.000
0.278	0.235	0.064	0.040	0.000

0.333	0.237	0.077	0.044	0.000
0.389	0.239	0.090	0.048	0.000
0.444	0.241	0.103	0.051	0.000
0.500	0.243	0.117	0.054	0.000
0.556	0.245	0.130	0.057	0.000
0.611	0.247	0.144	0.060	0.000
0.667	0.250	0.158	0.063	0.000
0.722	0.252	0.172	0.065	0.000
0.778	0.254	0.186	0.068	0.000
0.833	0.256	0.200	0.070	0.000
0.889	0.258	0.214	0.072	0.000
0.944	0.260	0.229	0.075	0.000
1.000	0.262	0.243	0.077	0.000
1.056	0.264	0.258	0.079	0.000
1.111	0.267	0.273	0.081	0.000
1.167	0.269	0.288	0.083	0.000
1.222	0.271	0.302	0.085	0.000
1.278	0.273	0.318	0.087	0.000
1.333	0.275	0.333	0.089	0.000
1.389	0.277	0.348	0.091	0.000
1.444	0.280	0.364	0.092	0.000
1.500	0.282	0.379	0.094	0.000
1.556	0.284	0.395	0.096	0.000
1.611	0.286	0.411	0.097	0.000
1.667	0.288	0.427	0.099	0.000
1.722	0.291	0.443	0.101	0.000
1.778	0.293	0.459	0.102	0.000
1.833	0.295	0.475	0.104	0.000
1.889	0.297	0.492	0.106	0.000
1.944	0.300	0.508	0.107	0.000
2.000	0.302	0.525	0.109	0.000
2.056	0.304	0.542	0.110	0.000
2.111	0.306	0.559	0.112	0.000
2.167	0.308	0.576	0.113	0.000
2.222	0.311	0.593	0.114	0.000
2.278	0.313	0.611	0.116	0.000
2.333	0.315	0.628	0.117	0.000
2.389	0.318	0.646	0.119	0.000
2.444	0.320	0.663	0.147	0.000
2.500	0.322	0.681	0.162	0.000
2.556	0.324	0.699	0.173	0.000
2.611	0.327	0.717	0.183	0.000
2.667	0.329	0.735	0.191	0.000
2.722	0.331	0.754	0.199	0.000
2.778	0.334	0.772	0.206	0.000
2.833	0.336	0.791	0.213	0.000
2.889	0.338	0.809	0.219	0.000
2.944	0.341	0.828	0.226	0.000
3.000	0.343	0.847	0.231	0.000
3.056	0.345	0.866	0.237	0.000
3.111	0.348	0.886	0.243	0.000
3.167	0.350	0.905	0.248	0.000
3.222	0.352	0.925	0.253	0.000
3.278	0.355	0.944	0.258	0.000
3.333	0.357	0.964	0.263	0.000
3.389	0.359	0.984	0.268	0.000
3.444	0.362	1.004	0.272	0.000
3.500	0.364	1.024	0.277	0.000
3.556	0.366	1.044	0.337	0.000
3.611	0.369	1.065	0.365	0.000
3.667	0.371	1.085	0.387	0.000
3.722	0.374	1.106	0.406	0.000
3.778	0.376	1.127	0.423	0.000
3.833	0.378	1.148	0.439	0.000
3.889	0.381	1.169	0.454	0.000
3.944	0.383	1.190	0.468	0.000
4.000	0.386	1.211	0.482	0.000
4.056	0.388	1.233	0.686	0.000
4.111	0.390	1.255	1.048	0.000
4.167	0.393	1.276	1.513	0.000
4.222	0.395	1.298	2.061	0.000

4.278	0.398	1.320	2.680	0.000
4.333	0.400	1.342	3.364	0.000
4.389	0.403	1.365	4.106	0.000
4.444	0.405	1.387	4.902	0.000
4.500	0.408	1.410	5.748	0.000
4.556	0.410	1.432	6.643	0.000
4.611	0.413	1.455	7.582	0.000
4.667	0.415	1.478	8.564	0.000
4.722	0.418	1.501	9.588	0.000
4.778	0.420	1.525	10.65	0.000
4.833	0.423	1.548	11.75	0.000
4.889	0.425	1.572	12.89	0.000
4.944	0.428	1.595	14.07	0.000
5.000	0.430	1.619	15.27	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	0.204
5 year	0.305
10 year	0.386
25 year	0.504
50 year	0.605
100 year	0.718

Flow Frequency Return Periods for Developed Unmitigated

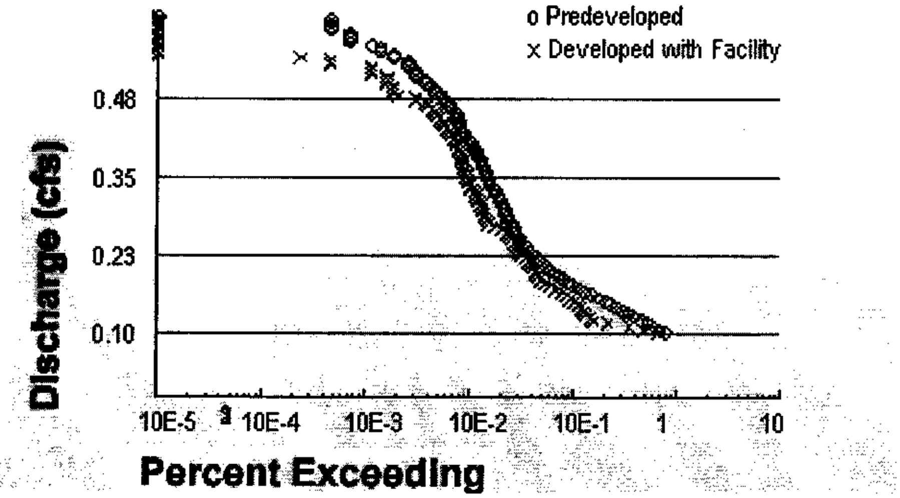
Return Period	Flow(cfs)
2 year	1.033
5 year	1.675
10 year	2.202
25 year	2.998
50 year	3.693
100 year	4.483

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.109
5 year	0.155
10 year	0.191
25 year	0.245
50 year	0.291
100 year	0.342

Yearly Peaks for Pre and Post Developed

Year	Predeveloped	Developed
1949	0.136	0.086
1950	0.383	0.108
1951	0.136	0.091
1952	0.161	0.084
1953	0.217	0.076
1954	0.355	0.107
1955	0.332	0.148
1956	0.223	0.187
1957	0.358	0.172
1958	0.344	0.102
1959	0.194	0.109
1960	0.176	0.112
1961	0.243	0.115
1962	0.312	0.092
1963	0.493	0.087
1964	0.174	0.084
1965	0.170	0.112
1966	0.104	0.082
1967	0.224	0.097
1968	0.252	0.128


o Predeveloped
x Developed with Facility
0.48
0.35
0.23
0.10
Discharge (cfs)
10E-5
10E-4
10E-3
10E-2
10E-1
1
10
Percent Exceeding

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: Brightwater_Water Surface LU
Site Address: Route 9
City : Woodinville
Report Date : 05/29/2003
Gage : Everett
Data Start : 1948
Data End : 1997
Precip Scale: 1.20

PREDEVELOPED LAND USE

Basin : Till Forest
Flows To : Outflow
GroundWater: No

Land Use	Acres
TILL FOREST:	9.6

DEVELOPED LAND USE
Basin : Water Surface
Flows To : Pond 1
GroundWater: No

Land Use	Acres
IMPERVIOUS:	9.6

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Outflow
Dimensions
Depth: 5ft.
Bottom Length: 476.61ft.
Bottom Width : 95.34ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 4.821 acre-ft.
Discharge Structure
Riser Height: 4 ft.
Riser Diameter: 18 ft.
Orifice 1 Diameter: 2.05 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 2.6 in. **Elevation:** 2.3 ft.
Orifice 3 Diameter: 3 in. **Elevation:** 3 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	1.043	0.000	0.000	0.000
0.056	1.048	0.058	0.026	0.000
0.111	1.052	0.116	0.037	0.000
0.167	1.056	0.175	0.045	0.000
0.222	1.061	0.234	0.052	0.000
0.278	1.065	0.293	0.058	0.000

0.333	1.070	0.352	0.064	0.000
0.389	1.074	0.412	0.069	0.000
0.444	1.078	0.471	0.074	0.000
0.500	1.083	0.531	0.078	0.000
0.556	1.087	0.592	0.082	0.000
0.611	1.092	0.652	0.086	0.000
0.667	1.096	0.713	0.090	0.000
0.722	1.100	0.774	0.094	0.000
0.778	1.105	0.835	0.097	0.000
0.833	1.109	0.897	0.101	0.000
0.889	1.114	0.959	0.104	0.000
0.944	1.118	1.021	0.107	0.000
1.000	1.123	1.083	0.110	0.000
1.056	1.127	1.145	0.113	0.000
1.111	1.132	1.208	0.116	0.000
1.167	1.136	1.271	0.119	0.000
1.222	1.141	1.334	0.122	0.000
1.278	1.145	1.398	0.125	0.000
1.333	1.150	1.462	0.127	0.000
1.389	1.154	1.526	0.130	0.000
1.444	1.159	1.590	0.133	0.000
1.500	1.163	1.654	0.135	0.000
1.556	1.168	1.719	0.138	0.000
1.611	1.172	1.784	0.140	0.000
1.667	1.177	1.849	0.142	0.000
1.722	1.181	1.915	0.145	0.000
1.778	1.186	1.981	0.147	0.000
1.833	1.190	2.047	0.149	0.000
1.889	1.195	2.113	0.152	0.000
1.944	1.199	2.179	0.154	0.000
2.000	1.204	2.246	0.156	0.000
2.056	1.209	2.313	0.158	0.000
2.111	1.213	2.380	0.160	0.000
2.167	1.218	2.448	0.162	0.000
2.222	1.222	2.516	0.165	0.000
2.278	1.227	2.584	0.167	0.000
2.333	1.231	2.652	0.201	0.000
2.389	1.236	2.721	0.224	0.000
2.444	1.241	2.789	0.240	0.000
2.500	1.245	2.858	0.254	0.000
2.556	1.250	2.928	0.266	0.000
2.611	1.254	2.997	0.277	0.000
2.667	1.259	3.067	0.288	0.000
2.722	1.264	3.137	0.297	0.000
2.778	1.268	3.208	0.307	0.000
2.833	1.273	3.278	0.315	0.000
2.889	1.278	3.349	0.324	0.000
2.944	1.282	3.420	0.332	0.000
3.000	1.287	3.491	0.340	0.000
3.056	1.292	3.563	0.403	0.000
3.111	1.296	3.635	0.433	0.000
3.167	1.301	3.707	0.458	0.000
3.222	1.306	3.779	0.480	0.000
3.278	1.310	3.852	0.500	0.000
3.333	1.315	3.925	0.518	0.000
3.389	1.320	3.998	0.536	0.000
3.444	1.324	4.072	0.552	0.000
3.500	1.329	4.145	0.568	0.000
3.556	1.334	4.219	0.583	0.000
3.611	1.338	4.294	0.598	0.000
3.667	1.343	4.368	0.612	0.000
3.722	1.348	4.443	0.626	0.000
3.778	1.353	4.518	0.639	0.000
3.833	1.357	4.593	0.652	0.000
3.889	1.362	4.669	0.664	0.000
3.944	1.367	4.744	0.677	0.000
4.000	1.372	4.821	0.689	0.000
4.056	1.376	4.897	0.892	0.000
4.111	1.381	4.973	1.253	0.000
4.167	1.386	5.050	1.717	0.000
4.222	1.391	5.127	2.265	0.000

4.278	1.395	5.205	2.884	0.000
4.333	1.400	5.282	3.567	0.000
4.389	1.405	5.360	4.309	0.000
4.444	1.410	5.439	5.105	0.000
4.500	1.414	5.517	5.952	0.000
4.556	1.419	5.596	6.846	0.000
4.611	1.424	5.675	7.786	0.000
4.667	1.429	5.754	8.769	0.000
4.722	1.434	5.833	9.793	0.000
4.778	1.438	5.913	10.86	0.000
4.833	1.443	5.993	11.96	0.000
4.889	1.448	6.074	13.10	0.000
4.944	1.453	6.154	14.27	0.000
5.000	1.458	6.235	15.48	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

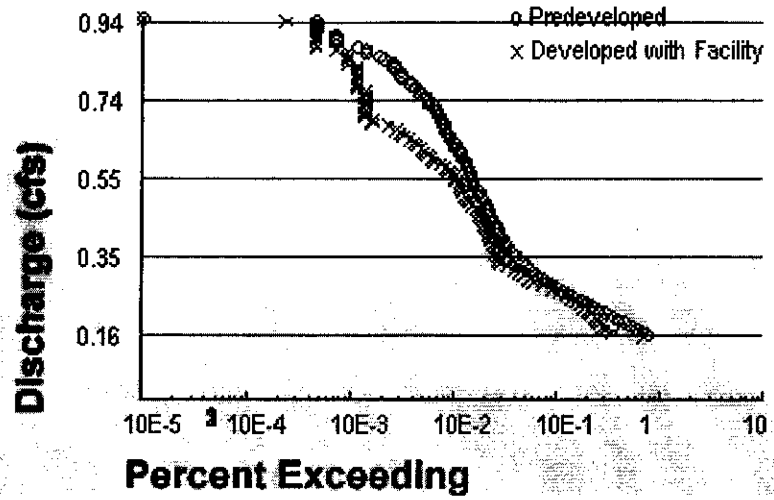
Return Period	Flow(cfs)
2 year	0.315
5 year	0.473
10 year	0.598
25 year	0.781
50 year	0.937
100 year	1.112

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.183
5 year	0.272
10 year	0.345
25 year	0.455
50 year	0.551
100 year	0.661

Yearly Peaks for Pre and Post Developed

Year	Predeveloped	Developed
1949	0.210	0.153
1950	0.592	0.164
1951	0.211	0.139
1952	0.250	0.134
1953	0.336	0.139
1954	0.550	0.154
1955	0.514	0.287
1956	0.346	0.320
1957	0.555	0.211
1958	0.533	0.152
1959	0.301	0.155
1960	0.272	0.163
1961	0.376	0.286
1962	0.482	0.138
1963	0.764	0.151
1964	0.270	0.124
1965	0.264	0.162
1966	0.162	0.144
1967	0.346	0.147
1968	0.390	0.163
1969	0.591	0.151
1970	0.209	0.151
1971	0.332	0.337
1972	0.256	0.153
1973	0.217	0.206
1974	0.284	0.179
1975	0.231	0.135
1976	0.201	0.159
1977	0.184	0.149


o Predeveloped
x Developed with Facility
0.94
0.74
0.55
0.35
0.16
Discharge (cfs)
10E-5
10E-4
10E-3
10E-2
10E-1
1
10
Percent Exceeding

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: BWarch052903
Site Address:
City :
Report Date : 05/29/2003
Gage : Everett
Data Start : 1948
Data End : 1997
Precip Scale: 1.20

PREDEVELOPED LAND USE

Basin : Basin 1
Flows To : Outflow
GroundWater: No

Land Use	Acres
TILL FOREST:	9.4

DEVELOPED LAND USE
Basin : Basin 1
Flows To : Pond 1
GroundWater: No

Land Use	Acres
IMPERVIOUS:	9.4

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Outflow
Dimensions
Depth: 5ft.
Bottom Length: 480ft.
Bottom Width : 95ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 4.839 acre-ft.
Discharge Structure
Riser Height: 4 ft.
Riser Diameter: 18 ft.
Orifice 1 Diameter: 2 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 3.07 in. **Elevation:** 2.668 ft.
Orifice 3 Diameter: 1.9 in. **Elevation:** 3 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	1.047	0.000	0.000	0.000
0.056	1.051	0.058	0.025	0.000
0.111	1.056	0.117	0.035	0.000
0.167	1.060	0.176	0.043	0.000
0.222	1.064	0.235	0.050	0.000
0.278	1.069	0.294	0.055	0.000

0.333	1.073	0.353	0.061	0.000
0.389	1.078	0.413	0.066	0.000
0.444	1.082	0.473	0.070	0.000
0.500	1.087	0.533	0.074	0.000
0.556	1.091	0.594	0.078	0.000
0.611	1.096	0.655	0.082	0.000
0.667	1.100	0.716	0.086	0.000
0.722	1.104	0.777	0.089	0.000
0.778	1.109	0.838	0.093	0.000
0.833	1.113	0.900	0.096	0.000
0.889	1.118	0.962	0.099	0.000
0.944	1.122	1.024	0.102	0.000
1.000	1.127	1.087	0.105	0.000
1.056	1.131	1.149	0.108	0.000
1.111	1.136	1.212	0.111	0.000
1.167	1.140	1.276	0.113	0.000
1.222	1.145	1.339	0.116	0.000
1.278	1.149	1.403	0.119	0.000
1.333	1.154	1.467	0.121	0.000
1.389	1.158	1.531	0.124	0.000
1.444	1.163	1.596	0.126	0.000
1.500	1.167	1.660	0.129	0.000
1.556	1.172	1.725	0.131	0.000
1.611	1.177	1.791	0.133	0.000
1.667	1.181	1.856	0.136	0.000
1.722	1.186	1.922	0.138	0.000
1.778	1.190	1.988	0.140	0.000
1.833	1.195	2.054	0.142	0.000
1.889	1.199	2.120	0.144	0.000
1.944	1.204	2.187	0.146	0.000
2.000	1.209	2.254	0.149	0.000
2.056	1.213	2.322	0.151	0.000
2.111	1.218	2.389	0.153	0.000
2.167	1.222	2.457	0.155	0.000
2.222	1.227	2.525	0.157	0.000
2.278	1.232	2.593	0.159	0.000
2.333	1.236	2.662	0.160	0.000
2.389	1.241	2.731	0.162	0.000
2.444	1.245	2.800	0.164	0.000
2.500	1.250	2.869	0.166	0.000
2.556	1.255	2.938	0.168	0.000
2.611	1.259	3.008	0.170	0.000
2.667	1.264	3.078	0.172	0.000
2.722	1.269	3.149	0.231	0.000
2.778	1.273	3.219	0.257	0.000
2.833	1.278	3.290	0.277	0.000
2.889	1.283	3.361	0.295	0.000
2.944	1.287	3.433	0.310	0.000
3.000	1.292	3.504	0.325	0.000
3.056	1.297	3.576	0.360	0.000
3.111	1.301	3.648	0.382	0.000
3.167	1.306	3.721	0.400	0.000
3.222	1.311	3.794	0.418	0.000
3.278	1.315	3.866	0.433	0.000
3.333	1.320	3.940	0.448	0.000
3.389	1.325	4.013	0.463	0.000
3.444	1.329	4.087	0.476	0.000
3.500	1.334	4.161	0.489	0.000
3.556	1.339	4.235	0.502	0.000
3.611	1.344	4.310	0.514	0.000
3.667	1.348	4.384	0.526	0.000
3.722	1.353	4.459	0.537	0.000
3.778	1.358	4.535	0.549	0.000
3.833	1.363	4.610	0.559	0.000
3.889	1.367	4.686	0.570	0.000
3.944	1.372	4.762	0.580	0.000
4.000	1.377	4.839	0.591	0.000
4.056	1.382	4.915	0.792	0.000
4.111	1.386	4.992	1.151	0.000
4.167	1.391	5.069	1.614	0.000
4.222	1.396	5.147	2.160	0.000

4.278	1.401	5.224	2.777	0.000
4.333	1.406	5.302	3.459	0.000
4.389	1.410	5.381	4.199	0.000
4.444	1.415	5.459	4.994	0.000
4.500	1.420	5.538	5.839	0.000
4.556	1.425	5.617	6.732	0.000
4.611	1.430	5.696	7.670	0.000
4.667	1.434	5.776	8.651	0.000
4.722	1.439	5.855	9.674	0.000
4.778	1.444	5.936	10.74	0.000
4.833	1.449	6.016	11.84	0.000
4.889	1.454	6.097	12.97	0.000
4.944	1.459	6.177	14.15	0.000
5.000	1.463	6.259	15.36	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	0.309
5 year	0.463
10 year	0.585
25 year	0.765
50 year	0.918
100 year	1.089

Flow Frequency Return Periods for Developed Unmitigated

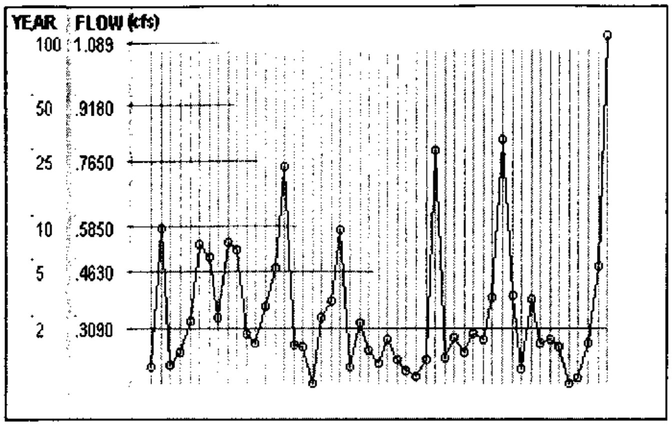
Return Period	Flow(cfs)
2 year	3.383
5 year	4.503
10 year	5.295
25 year	6.356
50 year	7.191
100 year	8.064

Flow Frequency Return Periods for Developed Mitigated

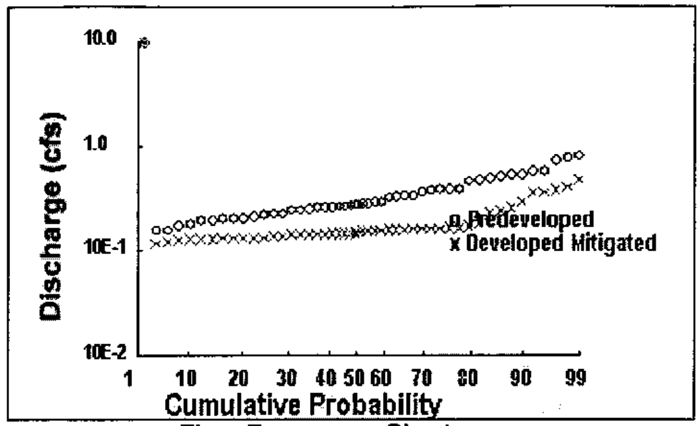
Return Period	Flow(cfs)
2 year	0.166
5 year	0.245
10 year	0.311
25 year	0.413
50 year	0.503
100 year	0.607

Yearly Peaks for Pre and Post Developed

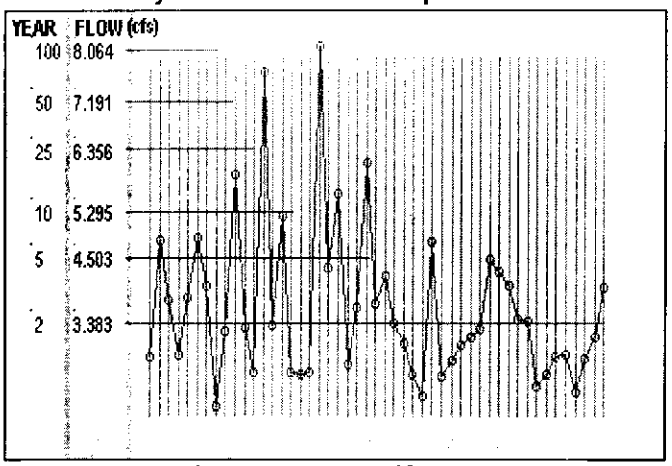
Year	Predeveloped	Developed
1949	0.206	0.145
1950	0.580	0.157
1951	0.207	0.133
1952	0.245	0.128
1953	0.329	0.133
1954	0.538	0.146
1955	0.503	0.294
1956	0.339	0.357
1957	0.543	0.161
1958	0.522	0.145
1959	0.295	0.148
1960	0.267	0.155
1961	0.368	0.242
1962	0.472	0.130
1963	0.748	0.144
1964	0.265	0.118
1965	0.258	0.153
1966	0.158	0.138
1967	0.339	0.141
1968	0.382	0.154



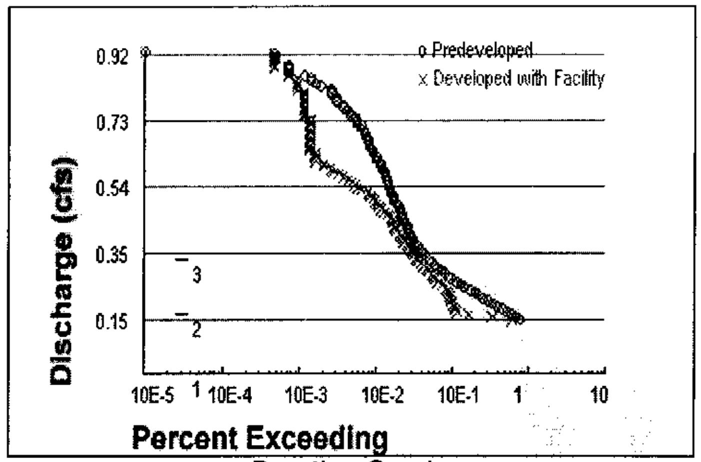
Yearly Peaks for Predeveloped



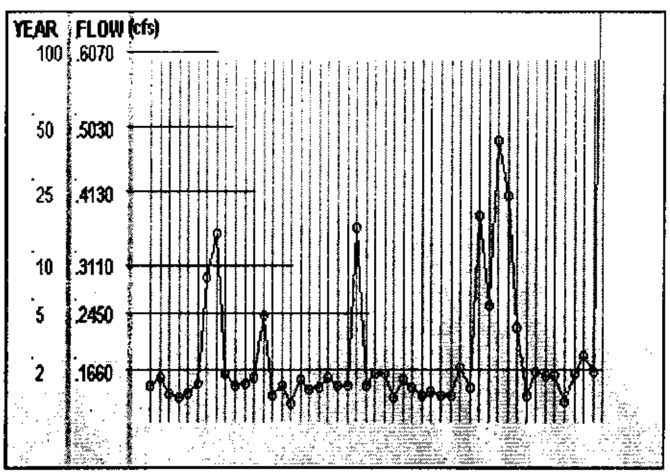
Flow Frequency Chart



Yearly Peaks for developed W/O Pond



Duration Graph



Yearly Peaks for Developed W/Pond

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: BWarch052903_RD
Site Address:
City :
Report Date : 05/29/2003
Gage : Everett
Data Start : 1948
Data End : 1997
Precip Scale: 1.20

PREDEVELOPED LAND USE

Basin : Basin 1
Flows To : Outflow
GroundWater: No

Land Use	Acres
TILL FOREST:	8.3

DEVELOPED LAND USE
Basin : Basin 1
Flows To : Pond 1
GroundWater: No

Land Use	Acres
IMPERVIOUS:	8.3

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Outflow
Dimensions
Depth: 5ft.
Bottom Length: 455.1ft.
Bottom Width : 90.98ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 4.421 acre-ft.
Discharge Structure
Riser Height: 4 ft.
Riser Diameter: 18 ft.
Orifice 1 Diameter: 1.8 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 2.88 in. **Elevation:** 2.668 ft.
Orifice 3 Diameter: 1.73 in. **Elevation:** 3 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.951	0.000	0.000	0.000
0.056	0.955	0.053	0.020	0.000
0.111	0.959	0.106	0.028	0.000
0.167	0.963	0.159	0.035	0.000
0.222	0.967	0.213	0.040	0.000
0.278	0.971	0.267	0.045	0.000

0.333	0.976	0.321	0.049	0.000
0.389	0.980	0.375	0.053	0.000
0.444	0.984	0.430	0.057	0.000
0.500	0.988	0.485	0.060	0.000
0.556	0.993	0.540	0.063	0.000
0.611	0.997	0.595	0.067	0.000
0.667	1.001	0.650	0.069	0.000
0.722	1.005	0.706	0.072	0.000
0.778	1.010	0.762	0.075	0.000
0.833	1.014	0.818	0.078	0.000
0.889	1.018	0.875	0.080	0.000
0.944	1.022	0.931	0.083	0.000
1.000	1.027	0.988	0.085	0.000
1.056	1.031	1.046	0.087	0.000
1.111	1.035	1.103	0.090	0.000
1.167	1.039	1.161	0.092	0.000
1.222	1.044	1.218	0.094	0.000
1.278	1.048	1.277	0.096	0.000
1.333	1.052	1.335	0.098	0.000
1.389	1.057	1.393	0.100	0.000
1.444	1.061	1.452	0.102	0.000
1.500	1.065	1.511	0.104	0.000
1.556	1.070	1.571	0.106	0.000
1.611	1.074	1.630	0.108	0.000
1.667	1.078	1.690	0.110	0.000
1.722	1.083	1.750	0.112	0.000
1.778	1.087	1.810	0.113	0.000
1.833	1.091	1.871	0.115	0.000
1.889	1.096	1.931	0.117	0.000
1.944	1.100	1.992	0.119	0.000
2.000	1.104	2.054	0.120	0.000
2.056	1.109	2.115	0.122	0.000
2.111	1.113	2.177	0.124	0.000
2.167	1.117	2.239	0.125	0.000
2.222	1.122	2.301	0.127	0.000
2.278	1.126	2.363	0.128	0.000
2.333	1.131	2.426	0.130	0.000
2.389	1.135	2.489	0.132	0.000
2.444	1.139	2.552	0.133	0.000
2.500	1.144	2.616	0.135	0.000
2.556	1.148	2.679	0.136	0.000
2.611	1.153	2.743	0.138	0.000
2.667	1.157	2.807	0.139	0.000
2.722	1.161	2.872	0.191	0.000
2.778	1.166	2.936	0.214	0.000
2.833	1.170	3.001	0.232	0.000
2.889	1.175	3.066	0.247	0.000
2.944	1.179	3.132	0.261	0.000
3.000	1.184	3.198	0.273	0.000
3.056	1.188	3.263	0.303	0.000
3.111	1.193	3.330	0.321	0.000
3.167	1.197	3.396	0.337	0.000
3.222	1.201	3.463	0.352	0.000
3.278	1.206	3.529	0.366	0.000
3.333	1.210	3.597	0.378	0.000
3.389	1.215	3.664	0.391	0.000
3.444	1.219	3.731	0.402	0.000
3.500	1.224	3.799	0.413	0.000
3.556	1.228	3.867	0.424	0.000
3.611	1.233	3.936	0.435	0.000
3.667	1.237	4.004	0.445	0.000
3.722	1.242	4.073	0.455	0.000
3.778	1.246	4.142	0.464	0.000
3.833	1.251	4.212	0.474	0.000
3.889	1.256	4.281	0.483	0.000
3.944	1.260	4.351	0.492	0.000
4.000	1.265	4.421	0.500	0.000
4.056	1.269	4.492	0.700	0.000
4.111	1.274	4.563	1.058	0.000
4.167	1.278	4.633	1.519	0.000
4.222	1.283	4.705	2.064	0.000

4.278	1.287	4.776	2.680	0.000
4.333	1.292	4.848	3.360	0.000
4.389	1.297	4.919	4.099	0.000
4.444	1.301	4.992	4.893	0.000
4.500	1.306	5.064	5.737	0.000
4.556	1.310	5.137	6.628	0.000
4.611	1.315	5.210	7.565	0.000
4.667	1.320	5.283	8.545	0.000
4.722	1.324	5.356	9.567	0.000
4.778	1.329	5.430	10.63	0.000
4.833	1.333	5.504	11.73	0.000
4.889	1.338	5.578	12.86	0.000
4.944	1.343	5.653	14.04	0.000
5.000	1.347	5.727	15.24	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	0.272
5 year	0.409
10 year	0.517
25 year	0.675
50 year	0.81
100 year	0.961

Flow Frequency Return Periods for Developed Unmitigated

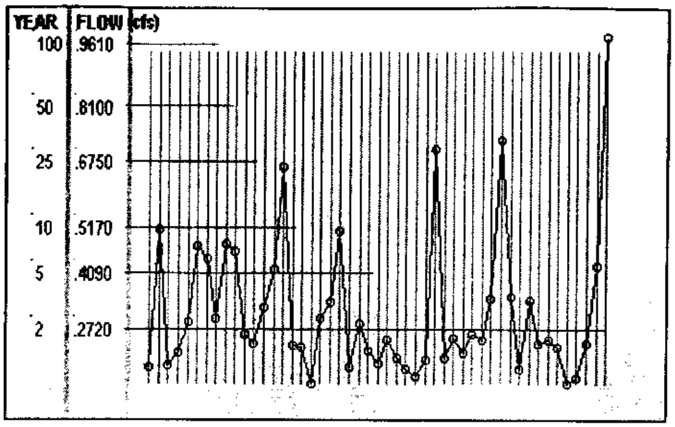
Return Period	Flow(cfs)
2 year	2.987
5 year	3.976
10 year	4.675
25 year	5.612
50 year	6.349
100 year	7.121

Flow Frequency Return Periods for Developed Mitigated

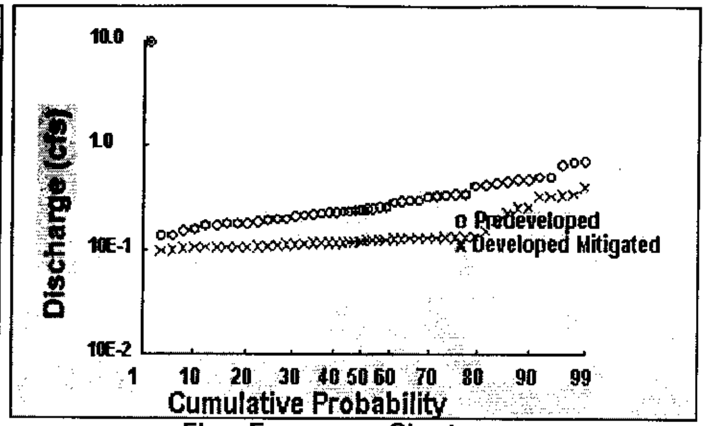
Return Period	Flow(cfs)
2 year	0.138
5 year	0.21
10 year	0.27
25 year	0.364
50 year	0.449
100 year	0.548

Yearly Peaks for Pre and Post Developed

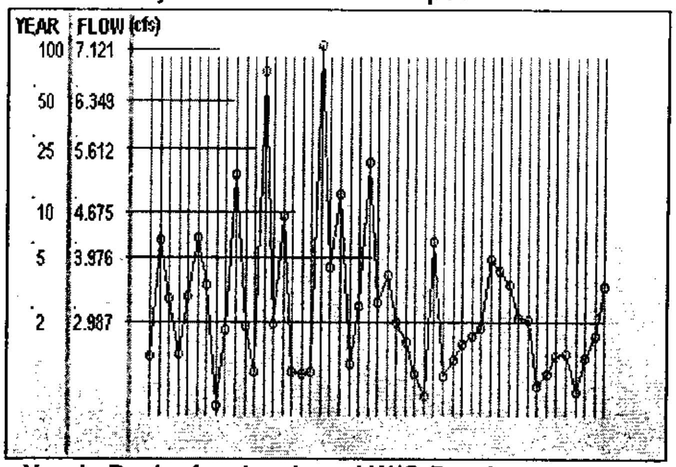
Year	Predeveloped	Developed
1949	0.182	0.119
1950	0.512	0.129
1951	0.183	0.112
1952	0.216	0.106
1953	0.291	0.109
1954	0.475	0.120
1955	0.444	0.264
1956	0.299	0.331
1957	0.480	0.131
1958	0.461	0.121
1959	0.260	0.121
1960	0.235	0.126
1961	0.325	0.230
1962	0.417	0.106
1963	0.660	0.120
1964	0.234	0.099
1965	0.228	0.125
1966	0.140	0.114
1967	0.299	0.119
1968	0.337	0.128



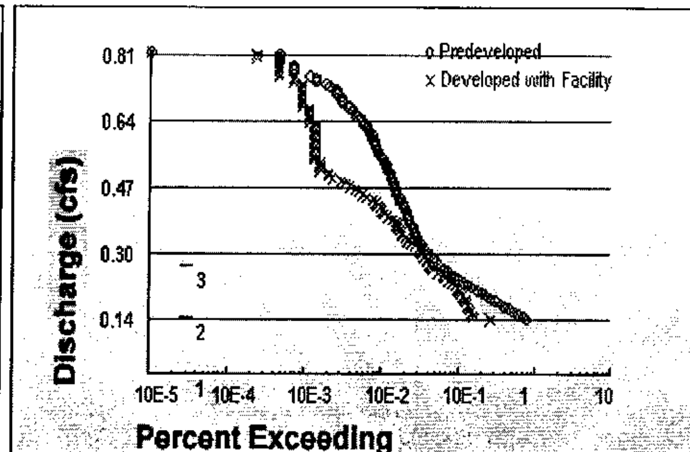
Yearly Peaks for Predeveloped



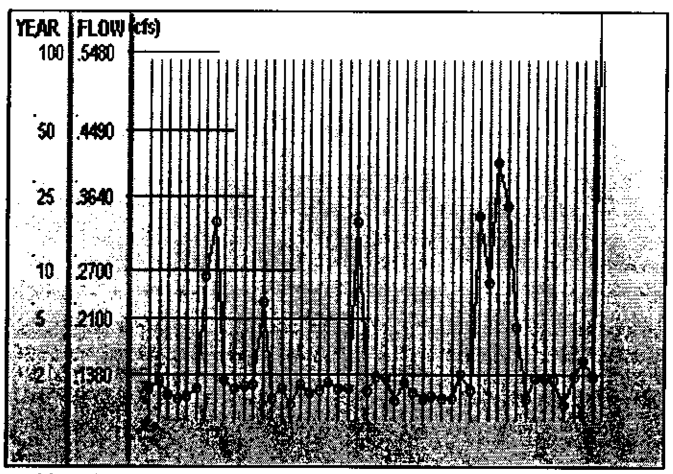
Flow Frequency Chart



Yearly Peaks for developed W/O Pond



Duration Graph



Yearly Peaks for Developed W/Pond

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: Brightwater_Impervious LU
Site Address: Route 9
City : Woodinville
Report Date : 05/29/2003
Gage : Everett
Data Start : 1948
Data End : 1997
Precip Scale: 1.20

PREDEVELOPED LAND USE

Basin : Till Forest
Flows To : Outflow
GroundWater: No

Land Use	Acres
TILL FOREST:	8.9

DEVELOPED LAND USE
Basin : Impervious Area
Flows To : Pond 1
GroundWater: No

Land Use	Acres
IMPERVIOUS:	8.9

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Outflow
Dimensions
Depth: 5ft.
Bottom Length: 471ft.
Bottom Width : 94.22ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 4.716 acre-ft.
Discharge Structure
Riser Height: 4 ft.
Riser Diameter: 18 ft.
Orifice 1 Diameter: 1.86 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 2.8 in. **Elevation:** 2.5 ft.
Orifice 3 Diameter: 3.8 in. **Elevation:** 3 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	1.019	0.000	0.000	0.000
0.056	1.023	0.057	0.021	0.000
0.111	1.027	0.114	0.030	0.000
0.167	1.032	0.171	0.037	0.000
0.222	1.036	0.228	0.043	0.000
0.278	1.040	0.286	0.048	0.000

0.333	1.045	0.344	0.052	0.000
0.389	1.049	0.402	0.057	0.000
0.444	1.054	0.461	0.061	0.000
0.500	1.058	0.519	0.064	0.000
0.556	1.062	0.578	0.068	0.000
0.611	1.067	0.637	0.071	0.000
0.667	1.071	0.697	0.074	0.000
0.722	1.075	0.756	0.077	0.000
0.778	1.080	0.816	0.080	0.000
0.833	1.084	0.876	0.083	0.000
0.889	1.089	0.937	0.086	0.000
0.944	1.093	0.997	0.088	0.000
1.000	1.097	1.058	0.091	0.000
1.056	1.102	1.119	0.093	0.000
1.111	1.106	1.180	0.096	0.000
1.167	1.111	1.242	0.098	0.000
1.222	1.115	1.304	0.100	0.000
1.278	1.120	1.366	0.103	0.000
1.333	1.124	1.428	0.105	0.000
1.389	1.128	1.491	0.107	0.000
1.444	1.133	1.554	0.109	0.000
1.500	1.137	1.617	0.111	0.000
1.556	1.142	1.680	0.113	0.000
1.611	1.146	1.744	0.115	0.000
1.667	1.151	1.807	0.117	0.000
1.722	1.155	1.871	0.119	0.000
1.778	1.160	1.936	0.121	0.000
1.833	1.164	2.000	0.123	0.000
1.889	1.169	2.065	0.125	0.000
1.944	1.173	2.130	0.127	0.000
2.000	1.178	2.195	0.128	0.000
2.056	1.182	2.261	0.130	0.000
2.111	1.187	2.327	0.132	0.000
2.167	1.191	2.393	0.134	0.000
2.222	1.196	2.459	0.135	0.000
2.278	1.200	2.526	0.137	0.000
2.333	1.205	2.593	0.139	0.000
2.389	1.209	2.660	0.140	0.000
2.444	1.214	2.727	0.142	0.000
2.500	1.219	2.795	0.144	0.000
2.556	1.223	2.862	0.194	0.000
2.611	1.228	2.930	0.215	0.000
2.667	1.232	2.999	0.232	0.000
2.722	1.237	3.067	0.247	0.000
2.778	1.241	3.136	0.260	0.000
2.833	1.246	3.205	0.272	0.000
2.889	1.251	3.275	0.283	0.000
2.944	1.255	3.344	0.293	0.000
3.000	1.260	3.414	0.303	0.000
3.056	1.264	3.484	0.402	0.000
3.111	1.269	3.555	0.448	0.000
3.167	1.274	3.625	0.485	0.000
3.222	1.278	3.696	0.517	0.000
3.278	1.283	3.767	0.546	0.000
3.333	1.287	3.839	0.573	0.000
3.389	1.292	3.910	0.598	0.000
3.444	1.297	3.982	0.622	0.000
3.500	1.301	4.054	0.644	0.000
3.556	1.306	4.127	0.666	0.000
3.611	1.311	4.199	0.686	0.000
3.667	1.315	4.272	0.706	0.000
3.722	1.320	4.346	0.725	0.000
3.778	1.325	4.419	0.744	0.000
3.833	1.329	4.493	0.762	0.000
3.889	1.334	4.567	0.779	0.000
3.944	1.339	4.641	0.796	0.000
4.000	1.343	4.716	0.813	0.000
4.056	1.348	4.790	1.021	0.000
4.111	1.353	4.865	1.386	0.000
4.167	1.358	4.941	1.855	0.000
4.222	1.362	5.016	2.407	0.000

4.278	1.367	5.092	3.030	0.000
4.333	1.372	5.168	3.717	0.000
4.389	1.376	5.244	4.463	0.000
4.444	1.381	5.321	5.263	0.000
4.500	1.386	5.398	6.113	0.000
4.556	1.391	5.475	7.011	0.000
4.611	1.395	5.552	7.955	0.000
4.667	1.400	5.630	8.941	0.000
4.722	1.405	5.708	9.968	0.000
4.778	1.410	5.786	11.04	0.000
4.833	1.414	5.865	12.14	0.000
4.889	1.419	5.943	13.28	0.000
4.944	1.424	6.022	14.46	0.000
5.000	1.429	6.101	15.67	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

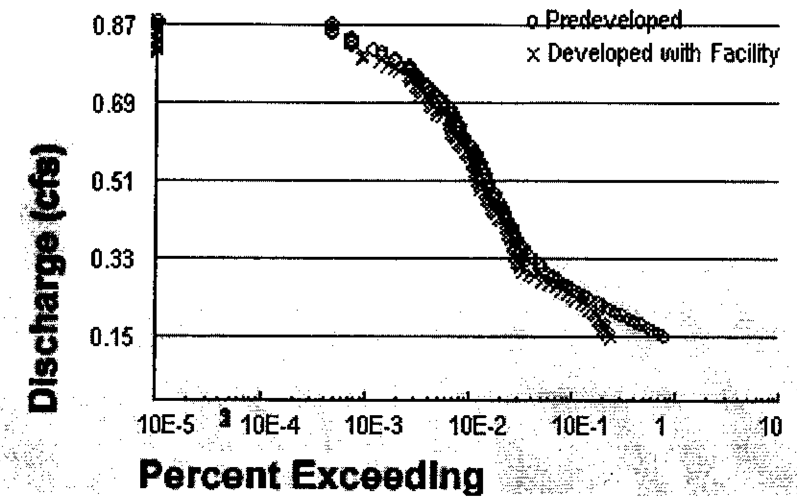
Return Period	Flow(cfs)
2 year	0.292
5 year	0.438
10 year	0.554
25 year	0.724
50 year	0.869
100 year	1.031

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.155
5 year	0.244
10 year	0.321
25 year	0.441
50 year	0.551
100 year	0.679

Yearly Peaks for Pre and Post Developed

Year	Predeveloped	Developed
1949	0.195	0.127
1950	0.549	0.138
1951	0.196	0.120
1952	0.232	0.114
1953	0.312	0.117
1954	0.510	0.128
1955	0.476	0.279
1956	0.321	0.396
1957	0.514	0.140
1958	0.494	0.129
1959	0.279	0.130
1960	0.252	0.135
1961	0.349	0.262
1962	0.447	0.113
1963	0.708	0.128
1964	0.250	0.106
1965	0.245	0.134
1966	0.150	0.122
1967	0.321	0.127
1968	0.361	0.137
1969	0.548	0.127
1970	0.194	0.127
1971	0.308	0.428
1972	0.237	0.126
1973	0.201	0.144
1974	0.263	0.143
1975	0.214	0.113
1976	0.186	0.136
1977	0.171	0.122



0.87
0.69
0.51
0.33
0.15
Discharge (cfs)
o Predeveloped
x Developed with Facility
10E-5
10E-4
10E-3
10E-2
10E-1
1
10
Percent Exceeding

Route 9 Site – Water quality treatment

Futureexpansion Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype	Event
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss		
Futureexpansion	3.50	8.00	1.1691	8.90	SBUH/SCS	TYPE1A	2 yr
Futureexpansion	4.99	8.00	1.6839	8.90	SBUH/SCS	TYPE1A	10 yr
Futureexpansion	7.72	8.00	2.6444	8.90	SBUH/SCS	TYPE1A	100 yr

Drainage Area: Futureexpansion

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number	
Peak Factor:	484.00		SCS Abs:	0.20	
Storm Dur	24.00 hrs				
	Area	CN	TC		
Pervious	0.0000 ac	76.69	0.17 hrs		
Impervious	8.9000 ac	98.00	0.08 hrs		
Total	8.9000 ac				

Supporting Data:
Impervious CN Data:

Street/parking	98.00	8.9000 ac

Pervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered	0.00 ft	0.00%	10.0000	10.00 min

Impervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered	0.00 ft	0.00%	5.0000	5.00 min

Pond Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype	Event
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss		
Pond	3.78	8.00	1.2610	9.60	SBUH/SCS	TYPE1A	2 yr
Pond	5.38	8.00	1.8164	9.60	SBUH/SCS	TYPE1A	10 yr
Pond	8.33	8.00	2.8523	9.60	SBUH/SCS	TYPE1A	100 yr

Drainage Area: Pond

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number	
Peak Factor:	484.00		SCS Abs:	0.20	
Storm Dur	24.00 hrs				
	Area	CN	TC		
Pervious	0.0000 ac	76.69	0.17 hrs		
Impervious	9.6000 ac	98.00	0.08 hrs		
Total	9.6000 ac				

Supporting Data:
Impervious CN Data:

Street/parking	98.00	9.6000 ac

Pervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered	0.00 ft	0.00%	10.0000	10.00 min

Impervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered	0.00 ft	0.00%	5.0000	5.00 min

Road Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype	Event
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss		
Road	3.27	8.00	1.0902	8.30	SBUH/SCS	TYPE1A	2 yr
Road	4.65	8.00	1.5704	8.30	SBUH/SCS	TYPE1A	10 yr
Road	7.20	8.00	2.4661	8.30	SBUH/SCS	TYPE1A	100 yr

Drainage Area: Road

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number
Peak Factor:	484.00		SCS Abs:	0.20
Storm Dur	24.00 hrs			
	Area	CN	TC	
Pervious	0.0000 ac	76.69	0.17 hrs	
Impervious	8.3000 ac	98.00	0.08 hrs	
Total	8.3000 ac			

Supporting Data:

Impervious CN Data:

Street/parking	98.00	8.3000 ac

Pervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered	0.00 ft	0.00%	10.0000	10.00 min

Impervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered	0.00 ft	0.00%	5.0000	5.00 min

ATTACHMENT B - Selected Model Output for the Unocal Site

Unocal Site – Water quality treatment

Impervious Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype	Event
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss		
Impervious	8.81	8.00	2.9229	27.40	SBUH/SCS	TYPE1A	2 yr
Impervious	13.41	8.00	4.5042	27.40	SBUH/SCS	TYPE1A	10 yr
Impervious	18.61	8.00	6.3204	27.40	SBUH/SCS	TYPE1A	100 yr

Drainage Area: Impervious

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur	24.00 hrs					
	Area	CN	TC			
Pervious	0.0000 ac	86.00	0.08 hrs			
Impervious	27.4000 ac	98.00	0.08 hrs			
Total	27.4000 ac					
Supporting Data:						
Impervious CN Data:						
PAVEMENT/BUILDING		98.00	27.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered		0.00 ft	0.00%	5.0000	5.00 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Fixed	None Entered		0.00 ft	0.00%	5.0000	5.00 min

ATTACHMENT C - Unocal Stormwater Marine Discharge

Unocal Stormwater Marine Discharge

One option for the treated stormwater at the Unocal site is to discharge it through a submerged marine outfall. This attachment evaluates the required pipe diameter and hydraulic grade line for such an outfall. The pipe would need to convey the 100-year design flow from a detention pond on the Unocal site to a discharge point at –50 ft MLLW. As yet, several details of the stormwater basin and pipe have not been finalized. This attachment recommends increasing the inlet elevation to prevent backflow of salt water into the detention pond during extreme high tides, and evaluates the head required for three pipeline diameters.

Assumptions

The analysis was based on the following information.

- The site layout shows the stormwater detention pond in the northwest corner of the Unocal property, and a proposed alignment for the stormwater discharge pipe. Scaling from this layout indicates that the stormwater pipe would be approximately 2,000 feet long and would require three 90-degree bends and two 45-degree bends.
- Design flow rates are as shown in Table C-1.

TABLE C-1
Design Flow Rates

Recurrence Interval	Flow Rate (cubic feet per second)
6 months	7 cfs
2 year	11 cfs
10 years	18 cfs
100 years	27 cfs

- Proposed elevation for the inlet to the stormwater discharge pipe is (12 feet NAVD 88).
- Plastic, steel, or concrete pipe could be used for the stormwater discharge pipe.
- A density difference of 0.024 kg/m^3 between the stormwater and ambient Puget Sound water was used.

Analysis — Hydraulics

The extreme high tide at Edmonds is predicted to be 14.5 feet MLLW (12.21 feet NAVD 88) (COE, 2000). To prevent the possible backflow of salt water into the detention pond, the pipe invert elevation should exceed the maximum expected tidal elevation. Unless occasional salt water intrusion into the detention pond is acceptable, this requires the pipe inlet elevation to be raised to this level (12.21 feet NAVD 88).

The stormwater discharge requires enough head at the inlet to overcome friction within the discharge pipe and the pressure of the water level in Puget Sound, plus the density head resulting from the denser salt water. Table C-2 tabulates these head requirements for three pipe diameters: 36, 48, and 60 inches. Two tidal conditions are included in Table C-3 to illustrate the effect of designing to a lower tidal standard than the maximum expected tide. Mean higher high water (MHHW) is the average of the highest tide each tidal day, implying that the tidal elevation will exceed this level every other day on average. The tide is not expected to remain at these levels longer than 1 to 2 hours, so additional storage could allow the stormwater design goals to be met.

TABLE C-2
Calculated Hydraulic Head at Stormwater Inlet for Various Pipe Diameters and Two Friction Factors

Pipe Diameter (inches)	Tidal Eleva-tion (NAVD 88)	Density head (feet)	Friction losses, new pipe (f=0.011) (27 cfs)	Required Head (ft NAVD 88) (f=0.011)	Friction losses, old pipe (f=0.04) (27 cfs)	Required Head (ft NAVD 88) (f=0.04)
36	12.21 ft (high tide)	1.49	2.01	15.7	6.4	20.1
48	12.21 ft (high tide)	1.49	0.50	14.2	1.54	15.2
60	12.21 ft (high tide)	1.49	0.18	13.9	0.52	14.2
36	8.61 ft (MHHW)	1.41	2.01	12.0	6.4	16.4
48	8.61 ft (MHHW)	1.41	0.50	10.5	1.54	11.6
60	8.61 ft (MHHW)	1.41	0.18	10.2	0.52	10.5

MHHW = Mean higher high water
NAVD 88 = North American Vertical Datum 1988

TABLE C-3
Initial Dilution Values at Acute and Chronic Mixing Zones

Recurrence Interval	Flow Rate (cfs)	Acute MZ Minimum Dilution	Acute MZ Average Dilution	Chronic MZ Minimum Dilution	Chronic MZ Average Dilution
6 months	7 cfs	40	51	46	82
2 years	11 cfs	30	40	34	57
10 years	18 cfs	23	30	26	41
100 years	27 cfs	19	24	21	32

The friction losses included in Table C-3 include an estimate of minor losses attributable to an inlet (K = 0.25), three 90-degree bends (K = 0.3), and two 45-degree bends (K = 0.2). It is expected that further design detail will better define the minor losses and the exact pipeline length.

The stormwater pipe could potentially be constructed from steel, concrete, or plastic pipe. Table C-3 provides estimates using two assumed friction factors, one characteristic of a smooth steel or plastic pipe (f = 0.011), the other (f = 0.04) to include the effect of possible marine growth on the interior of the pipe. A concrete pipe would require a larger head than a steel or plastic pipe. The extent of any marine growth may depend on the amount of tidal flushing within the pipeline, the vertical profile of the pipe, and the pipeline material. The calculation and estimated friction factor were intended to give a conservative estimate of the effect of marine growth, but if substantial encrustation is anticipated, additional head may be required. If minimizing the required head is important, an analysis of the relative benefits of using a check valve-type structure to reduce marine growth may be appropriate.

Analysis – Dilution

The initial dilution of the stormwater discharge was estimated using the UM3 model in the U.S. Environmental Protection Agency's Visual Plumes package. The simulation conditions included 27 ambient density profiles collected with a conductivity, temperature, and depth (CTD) profiler at King County's Point Wells No. 2 station, approximately 2 miles to the south. Ambient current speeds and directions were obtained from a current meter record at King County's mooring 51, 0.5 mile offshore of the Unocal site. Current speeds representing the 10th, 30th, 50th, 70th, and 90th percentile speeds were used. Dilution predictions are summarized in Table C-3 for four discharge flow rates at the acute and chronic mixing zone boundaries. Ecology specifies the chronic mixing zone boundary as 200 feet plus the depth of the discharge. The acute mixing zone is defined as 10 percent of the chronic zone. A 48-inch-diameter outfall pipe was assumed for these calculations.

The dilutions shown in Table C-3 range from 19:1 to 51:1 at the acute mixing zone and from 21:1 to 82:1 at the chronic mixing zone. These dilutions are expected to be significantly larger than a shoreline discharge would provide, possibly by as much as a factor of 10 or more. The submerged discharge also provides a benefit of removing the discharge from the vicinity of the beach area and greatest area of human use.

Discussion

Currently, the bank elevation for the stormwater detention pond is not specified, resulting in an uncertain amount of head. The required head was evaluated for a range of stormwater pipe diameters. A pipe diameter in the range of 36 to 48 inches appears to be reasonable and will require a discharge elevation from the stormwater pond in the range of 15 to 20 feet NAVD 88. As the design is refined, more work should be done to better understand how marine growth would colonize the outfall pipe and potentially restrict the discharge. This discharge head could be further reduced by providing storage in the stormwater detention pond to offset lower discharge flows during the periods of the highest tide.

It is suggested that the outlet elevation from the stormwater pond be increased slightly, from 12 feet to greater than 12.21 feet, to prevent the inflow of salt water into the detention ponds during periods of extreme high tide. Alternatively, the addition of a check valve could be investigated. This could reduce the tidal flow through the pipe as well as restrict the growth of mussels and barnacles within the pipe. However, the check valve would increase the required head.

The predicted dilution at this stormwater discharge is expected to be at least 19:1 at the acute mixing zone and more than 21:1 at the chronic mixing zone. While a shoreline discharge was not considered in this evaluation, it is anticipated that discharging the stormwater at depth provides a significant improvement in dilution over a shoreline discharge.